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A GUIDE TO SILVICULTURAL PRACTICE

DISTRICT ONE

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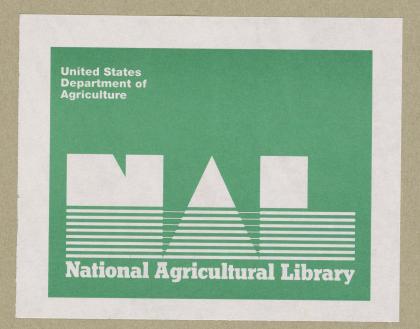
FOREST PATHOLOGY

Ву

James R. Weir, Ph.D., District Pathologist.

U. S. DEPARTMENT OF AGRICULTURE

FOREST SERVICE



FOREST SERVICE

A GUIDE TO SILVICULTURAL PRACTICE

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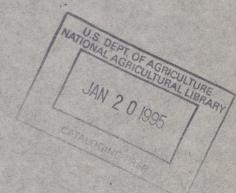
POREST PATHOLOGY

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By

James R. Weir, Ph. D., District Pathologist.

1913



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INTRODUCTION.

The cultural aims of the forester are to produce from year to year, at a certain growth ratio, the highest possible amount of merchantable wood. To bring this about it is necessary to protect the individuals of a forest, or the forest community, from such discuses as will threaten the production of this material. For the purpose of accusinting the field man with the nature of these diseases, their cause, and lastly the methods of central, this bulletin is prepared.

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Structure of the Tree

In order to have a clear conception of the way in which fungi are able to break down the vigor of a tree, it is appropriate to discuss the functions of the healthy tree and the structure of the normal wood.

In the coniferous and numerous broad leaf trees there is always a permanent increment taking place at regular intervals throughout the entire surface of the plant. This increment is originated and laid down through various changes of the three original primary tissues. The result of the activities of these tissues is usually referred to as the secondary thickening. This secondary thickening, or annual increment, is brought about by the division of the cells of the cambium which lies between the bark and the wood.

The cambium consists of very thin walled cells which at certain periods of the year are capable of rapid division, and are responsible for the yearly increment. This layer of embryonic tissue completely envelopes the entire woody portion of the tree and produces a new layer of wood every year. In the cross section of the sten these layers appear concentrically arranged and are known as annual rings. The sharp line of demarcation between rings is due to the microscopical structure of the cells composing them. The inner side of every ring consists of wide, thin walled cells and forms the spring wood, the outer of thicker cells and forms the autumn wood. Extending from the bank to the center of the wood cylinder are a series of modified cell elements

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forming the medullary rays. These consist of parenchyma and afford a means by which food materials are conveyed into the wood. The cross section of a stem presents in the variable form and thickness of its annual rings, therefore, a history of its growth and nutrition. Since these rings correspond to annual periods, they may be used in determining age.

Mature trees usually exhibit a striking variation in color between the cuter peripherical wood and the central part. Technically this is the heart and sap wood. The younger sap wood is more or less watery and of few rings in thickness. It is of great physiological importance since it is in this wood that the water is enabled to travel upward in the tree. The heart wood, dark colored in most trees, forms the main portion of the weed cylinder. It functions solely for the mechanical support of the tree and is otherwise unassential to its welfare. It is dead wood, and for this reason it is acted upon by wood destroying fungi.

The wood of conifers consists of very similar colls. These clonguted, pointed cells, known as tracheids, are characterized by having on their radial walls conspicuous bordered pits. The presence of these pits distinguishes the wood of conifers from that of broad leafed trees. Some of the tracheids may be highly specialised and of a parenchymatous nature for particular functions, and may be scattered throughout the thicker walled presenchymatous tracheids, or

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located in the medullary rays. They all, however, have the bordered pits. The successful transfer of water and food substances in case of injury to the trunk may depend on the position on the cell of these pits. Some of the wood tracheids are characterized by spiral thickenings on their inner walls, but are confined to the protoxylem (not of cambial origin) of the stem in most genera. In some cases spiral thickenings may be present in the tracheids of the secondary wood, and are provided with bordered pits. Douglas fir and larch are so characterized. In the former the spirals are present in both spring and summer tracheids, but are only in the summer wood of the Larch. The resin secreting tissues of coniferous wood very considerably, from single resin tracheids, and resin cella, to the more complex resin canals. The cimple resin tracheids are not ordinarily prominent in the higher Coniferme. The resin usually collects in a heavy layer about the periphery of the resin cell cavity. Pathological resin tissues may be formed in various centiers when injured by insects, sapsuckers and various other agents that do not normally produce them. Parasitic fungi and mistletoes may cause an abnormal and localized production of resin producing tissues in many conifers which is of considerable pethological significance.

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Normal Functions of the Tree.

The life of a tree is only maintained by an uninterrupted opportunity to exercise various functions.

The tree takes from its environment various raw materials and elaborates them to its use. This results in growth, with the attendant change in form and volume and adjustment to its environment. Lastly, since its length of life is limited, it produces individuals of the same species.

and physical processes, and are dependent on the influences of forces acting upon the various organs specialized for a particular work. These outer forces, or the environmental conditions, are food, oxygen transfer, water, warath, light and gravity. Of these the most important is oxygen and warnth. Without the former all life is impossible. Some of the bacteria are the only known forms of life that can exist without exygen. In like manner for all life functions a certain temperature over -0° is necessary. The optimum temperature for the most of the life functions lies between 25° and 25° C.

The result of the activities of various fungi by attacking the vital organs of the tree is to reduce its capacity to exercise the necessary functions for self maintenance.

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Mature and Cause of Disease.

The disturbances of the normal functions of a tree may be induced by a great variety of agencies, the resulting disessed conditions being manifest by more or less characteristic symptoms or signs, such as fruiting structures, resin flow. swellings, punk knots, cankers, shrinkage of branches, wilting and yellowing of leaves, etc. The observation and accurate description of symptoms is often difficult. Symptoms of disease may be of a general nature. This is due to the less organized nature of plants as compared to animals, or perceptions may differentiate imperfect symptoms when due to a variety of causes. Yellow and falling leaves, a very common indication of disease, may be caused by drought, temperature extremes, too much or too little light, excess of water at the roots, fungi, insects, poisenous gas, etc. Great caution is necessary, especially when the untrained eye has taken no notice of the collateral circumstances of the case. No one of the proximal causes may be solely responsible.

The reactions anhibited by some forest trees as expressed in form and structure under different conditions of growth, such as slope, crowding, or the peculiarities sometimes induced by sudden exposure on sales areas are not to be interpreted as indicative of unhealthy or diseased conditions.

The morphological and physiological changes are more to be considered as normal and purely within the ability of the tree to respond to varying amounts of light, heat, and nutritive materials. Since an ideal relation between the tree and ex-

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The reaction of the second property of the se

ternal factors is seldom, if ever, realized, a varying response on the part of the tree's organization is to be expected. Although the first operative forces receive a greater response in the early life of the tree and more or less determine its later form and structure, the fact that such early response may be diverted into other channels is only an index of the tree's recuperative ability, the work that every plant organization attempts to perform, vis: self-maintenance and perpetuation of its kind. It is clear that if a tree is to realize these two great functions in their fullness, it must possess a certain amount of functional flexibility. A tree may exhibit a loss of vicor due to certain indeterminable causes. The casual factors inducing the loss in vigor must necessarily retain the dominating influence until another or atronger impetus lays hold of the tree's organisation. The intermediate condition may then serve as merely a tiding over of adverse influences. Strictly pethological conditions may not appear since the life functions were not reduced to the lowest proportions. The chief component of a lower story forest often illustrates every stage of suppression and recovery indicated in the above statement and still appears as the climax forest in a state of vigor and health not shown by any other species of the stand. Only when the normal functions of the tree under the incluence of outside factors are so very greatly changed as to produce a positive injury to the living cell. can we speak of a strictly nathological condition. The possibility of a forest tree maintaining a more or less stable

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condition between the maximum and minimum of these factors or even to find its optimum depends upon its ability to cope with new environments. These may suddenly arise even in a permanent stand by fluctuations of climate, thinning, etc. Previous or early conditions of existence would also be of some significance. This may be illustrated as follows: If trees grown under south slope conditions were transplanted to north or northeast conditions, or if seedlings of the same species were grown under exactly the same cultural conditions, but at different temperatures, they would exhibit an entirely different response to the influences of frest and other weather conditions. The determination of the factors under which forest tree species in particular regions will attain their optimum development will often explain away an apparent pathological condition. To determine the danger line in the gradation between health and disease is often very difficult. Any factor that influences the amount and quality of the food supply of a forest stand determines very largely its general state of health. Since the attendant phonomenon of reduced vigor in such a case may be due to local conditions and may not have extended over so long a period as to induce so-called constitutional tendencies to disease, other causes must explain the general disability of certain members of a forest stand to maintain a high state of health. Probably no factor so over-rules all others in forest growth as the continual strife of trees with one another for space and light. For the more intolerant species this has a far greater significance from a stanspoint of disease than for the shade-loving or tolerant species.

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Claims of causation of disease and the factors concerned will be grouped differe thy to suit different cases. Bearing this in mind, the determining causes of disease, which are very numerous and often obscure, may be outlined as follows: I. Diseases caused by external agencies:

A. Inunimate (non-living) agents of disease.

- 1. Diseases induced by unfavorable soil conditions.
 - a. Chemical conditions of the soil.
 - b. Physical character of the soil.
- 2. Diseases induced by natural atmospheric phenomena.
 - a. Violent rain heavy dew, hail, sleet show, cold frost heat, light, sum, wind, drought, floods and lightning.
- 3. Diseases by non-atmospheric natural phonomena.
 - a. Avalanches, shifting sand, erosion, forest fires (started by lightning) and natural mechanical injuries.
- 4. Diseases induced by chemical injuries.
 - a. Illuminating gas, sewer gas, factory gases, smelter fumes, dust from cement works, acids, poisons and dyestuffs which pollute atreams.
- B. Animate (living) agents of disease.
 - 1. Animal agents of disease (resulting in mechanical injury.)
 - a. Matural wounds, nematode worms, mites, insects, rodents, grazing animals, and birds.
 - b. Artificial wounds resulting from man's activity.
 Fires, lumbering, may wires and climbers,
 electrical injuries from leaking wires,
 blazing, pruning and flooding of timbered
 areas.
 - 2. Vegetal agents of disease.

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- a. Smothering by lichens and non-parasitic fungi.
- b. Thenerogemic parasites.
 Mistletoe and various plants parasitio on roots.
- c. Cryptogemic parasites. Slime molds, bacteria, green algae and fungi

II. Diseases caused by internal agencies the so called functional diseases, sue to abnormal activities, mostly ensymatic, within the plant itself. Control of the state of the sta We althought are to think the episters real and the above over the state of the second con-Form a latter to the first and an arms of the second of the . This was subject to be to be both I had an in the party and the party of the part

The Mature and Development of Fungi.

The diseases of forest trees in most cases are due to fungi. A brief resume of the nature and development of these plants is necessary in order to appreciate their relation to disease.

The fungi form a large group of the spore or cell plants, in contrast to the seed or wascular plants. The latter originate from an embryo in the seed with the formation of cotyledons, the former develop from the undifferentiated contents of the se called spore. The spore germinates without the formation of cotyledons and develops at once by a rapid multiplication of like calls into a new plant. The most marked distinction between the fungi and seed plants lies in the development of their respective vegetative systems. The vegetative system of the seed plants (Phanerogens) is composed of the roots, stems and leaves, while in the spore plants (Cryptogens) the functions of those three highly differentiated organs are usually carried out by a single undifferentiated structure, the thallus (mycelium of fungi).

If one of our common wood destroying fungi is examined it will be found that the vogetative part of the fungus which ramifies through the wood cells of the bost consists of filementous elements (the hyphae.) These hyphae are characteristic of all fungi and produce the fruiting body of the fungus. While the hyphae of all fungi have more or less the same character, the fruiting structure arising from them are character-

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ized according to the manner in which the spores are produced by a great variation in form and structure.

A fungus may propogate itself by means of its vegetative syntem, by various minor or secondary bodies capable of germination and by apares. The most common method of propagation is by means of spores. Although the fungi consist of cells as do other plants, these cells are entirely devoid of chlorephyll. For this reason they are dependent upon organic substances for their nourishment, which explains their importance in plant disease. Under the influence of the sun the carbonic acid of the air taken up by the cells of green plants is broken up into carbondioxide and oxygen. Oxygen is given off and the carbon dioxide is combined to form starch and sugar. This method of nourishment is in great contrast to that of the fungi which must have food already prepared for them. They obtain this food from various substances. If it is derived from decaying or dead organic matter, the fungus is said to be a seprophyte. If the fungus mycelia invades the tissues of livin organisms (the host) it is said to be a parasite. The cellular tissues of the host are acted upon in various ways and disease results.

The spores of fungi are, as a rule, of very simple structure. They are of mycroscopical size, usually round to oblong and may consist of one or more cells. They are produced on or in various kinds of frustifications. Upon the form and structure of these frustifications the classification of the fungi is based.

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Systematically the fungi are divided into three major groups: Physomycetes (Algal-like, or lower fungi), Ascomycetes (sec-fungi), and Basidiomycetes (basidia-fungi). The last two groups constitute the higher fungi.

The <u>Physomycetes</u> are characterized by a continuous mycelium without cross walls. To this group belong some of the most important "damping-off" fungi, which cause great destruction of seedlings in forest tree nurseries.

The Ascempostes are characterized by the production of from 2. usually 8 spores in a sack-like structure, known as the ascus (plural asci). At maturity the spores are forceably expelled. The asci may originate singly or in Sroups from the perent mycelium, or may be housed in definite and characteristic fruiting bodies. These fruiting bodies are either open (apothecia) or closed (perithecia). After the asc1 are formed from appoint ascogenous hyphne sterile filements appear among them, the whole forming that is usually known as the hymenium. In some Ascomycetes a sexual process has been observed, but in many cases the anci originate without fertilization. In addition to the spores in the secus many Ascompostes produce various kinds of secondary spores (conidia). These are either out off from free standing conidiophores or originate in openial structures (pyonidia). This ability to produce several spore forms is semetimes called pleamorphism. Many of these spore forms have not been commested with the ascus type of spore production and are known as the inperfect fungi (Fungi Imperfecti).

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To the Ascometes belong some of the most important parasites of forest trees. The chestnut bark disease, leaf and needle east, many eankers on conifers, and various types of Vitches' brooms, are caused by Ascomycetes.

The Basidiomycetes include the large tree fungi and all such forms commonly known as toad stools and mushrooms. The forest tree rusts also belong in this group, which still retain, to a certain extent, a sexual mode of reproduction. In the majority of Basidiomycetes sexual reproduction has entirely disappeared. The spores of the Basidiomycetes are born usually in groups of four on special structures known as the basidium, which form a layer (hymenium) on the under side of the fruiting body. All the fungi which attack the heart wood of living trees belong in this group, and are classified according to form and arrangement of this fruiting layer. Some of the most important genera are Polyporus, Fomes, Trametes, Hyduum, Dacdales, Fheliota, Armillaria, etc.

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Methods of Infection by Fungi,

The uninjured bark upon the living tree is a natural protection against the entrance of most of the wood destroying fungi. Any opening through the bark caused by natural or artificial agencies exposes the sapwood or heartwood. If the exposed wood is not immediately protected, so is the case in most conifers, the wood dries out and checks. Spores of wood destroying funci find lodgment on the exposed surface, where they germinate and infect the tree. This is the method by which all the wood destroying funci, which do not normally attack the roots, enters the tree. A few wood destroying funci are parasitic. They are usually confined to the roots and may infect the tree without the intervention of wounds. These fungi may propagate themselves vegetatively by extending the mycelium from tree to tree through the forest litter. The true parasitic fungi, such as the rusts and many of the Ascomycotes, may educe infection on the younger parts of trees by direct penetration of the young bark, terminal buls, etc.

After a wood destroying fungus becomes established in the heart wood of its host the mycelium spreads up and form the trunk destroying the wood. After the mycelium reaches a cortain stage of development or maturity, a process hastened by the exhaustion of the food materials in the substratum, fruiting hodies may be developed at various points on the outside of the tree. These fruiting bodies ("punks", "conks"), may be the first noticeable indication of the presence of decay. Their number and location on the trunk is usually a good indi-

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cation of the amount of rot.

The Decay of Wood by Fungi.

Wood decay is always caused by fungi, sided by bacteria in later stares of decay. The action of the funcus on wood is a pure nutrient relationship. The demands of the different fungi for particular food substances may produce various changes in the wood, resulting in characteristic decays. Aside from certain natural fersentation processes set up by the respiration of the mycelium, there is usually a complete breaking down of the cell well elements through the influence of special engymes excreted by the mycelia. These engymes have the power to break down carbohydrates. Ists and albuminous compounds without themselves being changed in the process. Illustrative of the action of these enzymes is the hydrolization of starch into several intermediate substances. The aplitting up of reserve cellulose into various products is another example. These processes may mot be rapid in the wood. A fungus can only utilize those substances actually taken up by its mycelia. the amount depending upon the extent and demends upon its vegetative growth, as in the production of sporophores, etc. The breaking up of albuminous compounds may be brought about by different ensymes, working specifically at different stages of the disorganisation. These intermediate stages, first albumose, then peptone, and finally as the complete result of the disorganized albumens, the aminoacids, with the exception of the latter, still have much in common with the

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original compound. The wood, however, is greatly effected. The fact that the mycelia of our common wood destroying funci produce these engymes (ferments), enables them to bore through the cuticularised cellulese wells disorganising the cell content, and the wood structure in general. This is the work of most of the tree fungi with which we have to deal. The manifold variation in which the various species exhibit in breaking down the woody tissues show that there must be special or particular adaptations between certain fungi and the wood inhabited by thom. Also in the manner in which the disintegration is brought about. Some species dissolve from the woody cell wall conifering and cellulose only, leaving the lignified portion of the well. This action causes the familiar brown or earbonising rots. The enzymes of some fungi act principally on the lignin, leaving the cellulose. This setion causes the so called delignified or white rots. The fact that the entire groups of fungi may produce the same changes in the wood explains the seemingly constart character that the wood of different trees exhibit in decay. The variation in the structure of wood may influence the type of decay, but ordinarily the same characteristic rot is produced by any particular fungus, regardless of the species of tree on which it grows. This is true at least for some of our common wood destroying fungi. But is is unsufe to refer a rot in every case to a particular fungus when the sporophere is not found.

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Specific Description of Diseases.

Before presenting the practical aspects and relation of forest pathology to forest regulation, it is first necessary to become accusinted with a few of the most important factors causing discase in trees. The diseases to which our forest trees are subjected may be discussed, as previously indicated, in accordance as they are induced by various insumate and animate arents, such as atmospheric influences, soil, Cryptogemic and Phanerogemic plants, etc.

1. Injuries primarily resulting from causes other than Cryptogamic plants.

Results of Injury by Fire: We have a number of northwestern conifers which show great sensitiveness to high temperutures. The susceptibility to fire injury by these trees aside from any particularity of root system, foliage, etc., hinges in a large measure on the thinness of the bark as compared to their associates. Aside from the immediate destruction of immature and mature growth, the action of ground or surface fires is to produce a disposition of the alightly injured trees to all manner of disease of roots, trunk, and foliage. The more indirect consequences of fire would be the loss in the food producing capacity of the soil by washing, leaching, action of sun, wind, and growth of weeds and other nexious plants. From a pathological standpoint the destruction of the humas has a greater significance. The humus soil always is in an active state of decay, sided by its ability to retain moisture and by the immense number of oryptogemic organisms contained in it, many of which, as mycerrA TRANSPORT PROPERTY AND ALTERNATION

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hisa, are intimately associated with the roots of trees in the absorption of food and are, in some cases, apparently necessary for the growth of some of our commercially valuable species. The fact that the forest would may contain funguus forms injurious to forest trees is entirely offset by the invigorating effects of the humas on the growth of the trees, hence reducing the possible disposition to discuse of the aerial parts. Owing to the fact that this fertile bed is usually attractive on some sites to a second story growth of tolerant species, the cite is unfavorable for grasses, herbaceous plants, shrubs, etc., likely to be the alternate hosts of many heteroecious leaf and twig diseases.

Thether or not the natural succession of tolerant species in a type and their subsequent stabilization are to be considered a menace in every instance will depend on the disease attacking them. In most cases, in our own region, the diseases of tolerant species are not of economic importance on the intolerant species. On the other hand, the silvical significance of these tolerant species may semetimes be very great. The appearance on burned areas of forcet tree species other than those originally found in it is not always a menace by reason of any disease they might carry, and the transition species may not prove susceptible to the diseases of the primary stand. This is not always true in the case of other plants.

After a fire sufficiently intense as to destroy every vestige of humas and litter the succession of smaller plant life on some sites almost invariably establishes one or more plants that serve for the alternating hosts of some virulent

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needle or twig disease not found on the site before the fire.

The transition by fire of species into a new environment will then greatly intensify pathological conditions. It is likewise evident that the restoration of the belance between species will have some bearing on the history of diseases in the surrounding unburned areas or, as we have already indicated, on the health of the climax species of the area burned.

Probably the most immediate result of fire injury from the standpoint of what we shall here call disease is the appearance in the wood of fire injured trees of chromogenic fungi, in particular, the common map stain fungi, Geratostomella species.

These fungi color the dead wood of the wound, often penetrating well into the more vital portions of the map. In the case of western white pine, which invariably succembe within a few years after being injured by fire, the blue stain fungi repidly spreads throughout the entire sepwood and no amount of expedient work on the part of the logger can save the sap from staining. It has been determined that the mycelium of the bluing fungus is only prevented from entering the living supposed by the high water content of the cells as determining the presence of the necessary amount of experimented by the fungus.

The relation of basal fire scars to fungus attack is shown by the fact that out of 450 fire-scarred trees of all species and ages examined on sale areas in District One, 85 per cent were butt-rotted. The rot may have been present in some cases before the fermation of the scar, but its infrequent occurrence in unscarred trees on the case areas implies the im-

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portance of fire scars in relation to decay. On slightly scorehed trees hidden scars are formed, vis., the slightly checked bark remains intact over the injured pertien and may not fell away for a considerable period of time. These scars are a means of entrence for fungi. The cavity which usually forms between the bark and wood is a natural culture chamber and infection readily cours. In general trees with resincus wood show a greater number of large fire acars, but it is doubtful if the presence of reain in the wood has any greater significance then that it promotes the inflammability of the exposed wood in old fire acars, making them larger with every recurring fire.

"Mound rot", another injury reducing the quality of the wood of living forest trees is the discoloration of the exposed tissues on coming in centect with the sir, and the depredations of wood-boring insects. This "wound-ret", which may take place without the ecoperation of fungoid parasites, is often accredited to the bluing fungus or other fungi. As a matter of fact this early reaction to exposure is not a decay but a coloring up of the exposed wood through exidation of the cell substances and the action of enzymes. The real decomposition of the woody cell is only brought about by fungi and the secondition resulting from the chemical action of the numerous fungi which enter at the various types of wounds to be later described.

Influence of Soil on Diseases. It is frequently noted in the transition zones of different forest tree types which

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require different site conditions that some trees which have succeeded in establishing themselves in soggy, stony or poorly drained soils may show a stag-headed condition. In some esses the tap root is found decayed; in the absence of fungions insects, there is little room for soubt but that the sicking and reduced vigor of the tree is directly referably to the tensciously rocky, compact or soured condition of the soil. It is not generally entertained that an actual decomposition of wood results from a purely chemical action of the organic or inorganic acids of the soil, although this may be possible under very specific conditions of stagnation and insufficient section. The formantative action of bacteria and moulds, tegether with the presence of higher fungi, made more active by the constant conditions of moisture, no doubt are largely responsible for this type of root rot.

In wet soils underlaid by an impervious stratum of clay or other tenecious formations some forest trees fall under a very moderate wind when left unprotected. The "hard pan" does not admit of the penetration of the tap root to any depth and also retains the moisture comparatively near the surface. The horizontal roots of white pine and largh have been noted to bee up toward the surface or even above it under the influence of such conditions after the manner of certain swamp-growing trees, and presumably for the same purpose. Shallow rooting species, such as apruce, growing on the same site do not ordinarily show a root rot and for this reason are more wind firm.

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Atmospheric Influences as a Cause of Discase.

Prost injury: Prost shakes or checks are often very frequent in smooth-barked species, especially in regions of fluctuating and sudden abnormal temperatures. In the older are classes, much checks reduce the quality of the wood for the various technical purposes and open the trees to numerous wood-destroying fungi. The vitality of a tree may be in no wise impaired and the wound in many cases may be effectually healed, but is liable to re-open with the re-occurrence of severe frosts. Such inevitable factors can scarcely be controlled but the avoidance of "frost holes" or "frost belts" is to be recommended in silvical projects. From the standpoint of fungous enemies every frost checked tree should be marked for cutting in all timber sales.

who were and the younger parts of more mature forest growth frequently occurs. Premature or rapid transpiration due to "chimock winds" at a time when the roots are frequently occurs. Premature or rapid transpiration due to "chimock winds" at a time when the roots are frequent growth occurs. Premature or rapid transpiration due to "chimock winds" at a time when the roots are frequent in certain sections of Montana is an example of this type of injury. The wilting down of the terminal twice is often the means of various semi-

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parasitic leaf and twig fungi gaining entrance into the weakened but still living parts of the branch.

Heat Injury: It has already been indicated that thin-barked species are under certain conditions sensitive to high temperatures. This is frequently forcibly demonstrated by their reaction during long exposure and the direct rays of the sum. Providing the soil contains sufficient moisture by which the equilibrium between transpiration and the necessary water content of the living cell may be maintained, many of our confers, though not naturally occurring on a dry site, can withstand a great deal of atmospheric warmth after they once become established. When such is not the case, numerous instances have come to hand where trees have exhibited such a distinct falling off in increment and showed such peculiar colorations of the foliage that it necessitates proper precautions being taken in planting some species to prevent any undue exposure of soil and site.

enables older ago classes to withstand a considerable amount of drought and exposure, whereas young seedlings either in the nursery or in the open forest, or especially in clear outtings or burnings frequently succumb to the sun's best. An examination of the conditions surrounding both serial and subterranean portions of the seedlings during such periods, leaves no room for doubt but that the heat of the sun is the primary cause of death. In regard to mitigating the effects of exposure to the sun on natural reproduction, on all low

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level tracts where conditions are more ept to fluctuate and where the greatest injury appears proper protection should be and usually is provided by the rapid expostence of various kinds of plants. The annual and diumnal fluctuations of heat is greater in such situations and the relative busidity and the abundant precipitation of uneven or sountainous regions is not near so pronounced.

Injury to Isolated Trees: Aside from injury resulting from natural exposure to the sun, damage often results to vigorously growing trees on suddenly being exposed the edges of sale areas. The same may occur in the case of isolated seed trees, or blocks of trees left for the purpose of reseeding. The injury resulting from such exposure is in most cases due to the premature starting of the physiological functions in the spring before the ground has become sufficiently thaned to allow the absorption of water by the roots.

A form of heat injury frequently noted where trees are exposed to edges of outting areas, seed blocks, forest reads, etc., is the actual secrebing of the bark on the younger parts of older trees. Those of pole size are still more liable to this kind of injury. The bark dries out, carls up, and wounds are often formed of me mean proportions. This type of wound seldem protects itself by a flow of remin. Such trees, however, should be allowed to remain, if not diseases, as their removal would only expose others to injury.

Other Injuries. The density of the erewn of individual trees is not always sufficient to uphold any great amount of mnew, atill the elemeness with which young trees comptimes

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grow may collectively support a sufficient amount of snow to cause considerable breakage. The trees likewise become bent over and remain so long under the influence of the strain that they lose the ability to recurs their former position, and if they do not eventually die they become a manace to their neighhors. The openings thus made in the canopy of the stand are always a means of introducing injurious factors. Snow slides are by no means infrequent in the mountains of the Northwest and the damage resulting is is some cases very great, not only in the impodiate doctruction of valuable timber, but secondarily other dostructive agents, as fungi and innects, are introduced. After a slide once occurs, it is extremely difficult for nature to referest the area, as new elikes namelly follow the path of the old one. Since the Dature and general density of foliage determines in a large measure the retention of snow in the erown of forest trees, mixed foreste are to be recommended on all sites liable to snow injury. A cortain percentage of Larch in the stand, owing to the deciduous nature of its foliage, is desirable on such sites. The various root systems of the diffarent species in mixture is also a factor to be considered in combeting snow slides, the offsets of storms, strong winds, etc. As a protection to the more valuable stands on lower levels all procipitous slopes above wherever possible should be maintained in closed forest.

Lighthing. Lightning is a common source of injury to forest trees. Some species prove more sensitive and recover with greater difficulty from this form of injury than others. If the trees are not broken up and killed directly, they long, usually

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spiral, wounds leave the cambium and sapwood unprotected. By striking old, dry snegs lightning is very often the direct cause of forest fires. The influence of lightning on the growth of trees actually atruck is usually expressed by the socification of the cells of the amuel ring of the season so that the continuity of the nermal structure of the wood is broken, making a possible defect in the wood when used to suntain heavy locks. There is no practical means at hand to mitigate the dengers from lightning to forest growth, still known "lightning belts" might be avoided or species exploited that experience shows to be fairly free from this form of injury.

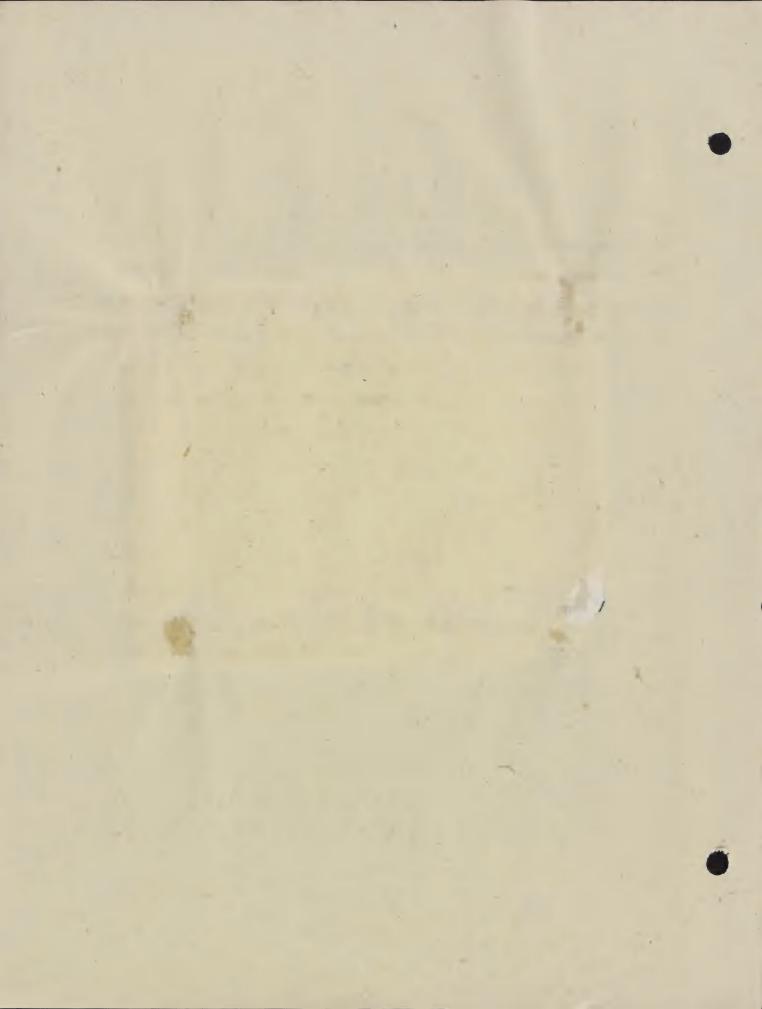
2. Diseases caused by Cryptoramic Plants, Funci.

Most of our valuable timber trees are subject to the attacks of a number of very destructive fungi. These attacking the trunk are directly dependent upon various types of wounds for entrance into the tree. These working in the roots and hasel portion of the trunk may or may not be dependent upon wounds. The virulence of those stracking the twice and readless may be greatly augmented by many of the unfavorable conditions indicated unfor atmospheric influences, still they are in most cases true parasites and may work great injury to the trees providing sufficient moisture is present. The most important fungous discusses of our western conifers will be briefly discussed seconding to their position on the host or the parts most affected.

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Fig. 1. Fomes pini
on Larix occidentalis
showing relation to rot.



Punci of the Prunk and Branches.

Wood Rotting Pungi: Fomes pini (ringscale fungus). (fig.1).

The sporophores of this fungus are either hoof or shell shaped, perennial, hard, woody, with a dark brown upper surface, rough, hairy when young, with concentric raised somes. The context is brown. The pores are usually large and round, semetimes deedsloid. The pore layer is stratified, indistinctly so in young or thin specimens. The underside of the sporophere is brown, usually lighter in color than the context.

fungus is very great. It is the chief enemy of the western white pine, but attacks practically all conifers. Transing the hosts of this fungus according to species most infected it would be in most regions of Idaho as follows: Thite pine, lerch, spruce, Douglas fir, ledgepole pine, coder, hemlock, and grand fir. Except under very special conditions, as in the case of root grafting, infection always takes place by means of spores and their ability to germinate, or at least the penetration of the hest by the mycelium, has been found to depend upon the freshness of the wound which is principally

All species of Polyporaceae with perennial hard, woody, distinetly or indistinctly stratified sporopheres are grouped in the genus Pomes.

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that of a branch and before it has had time to become thoroughly protected with resin. This explains why it is that the older age classes may be most frequently attacked. The heartwood of the branches is poor in resin and the wounds are left unprotected for a greater length of time, also the branch wounds of older trees are larger. The branch wounds of veterans are particularly susceptible to infection. The funcus may remain dermant in fairly young trees or species rich in resin and later bosome pronounced with the increasing age of the host, hence only the older age classes seem to be selected. The abundance of resin in the living serwood of resincus species, also of the outer heartwood prevents the promiscuous appearance of sporophorou and are always produced except in the case of the last stages of decay at points of deep wounding, old branch knots, fire scare, etc. For similar reasons the mycelium for long periods confines its activities to particular annular rings giving rise to the familiar "ring ret" or "Ring scale." Sporophores are usually not produced until a luxuriant mycelium has developed, indicating also that the decay is well advanced. These are points to be held in mind by markers. It is not uncommon to find sporophores measuring/ foot or more in breadth and showing an age of fifty or more years. At the same time numerous amaller appropheres may be produced from the same mycelium.

cocurrence of the fungus and amount of damage done, but it cocurs in all forest types from that of the yellow pine to the zone of the alpine fir. The prevalence of the fungus also dopends on the frequency and nature of the injuries to which stands—29-

With last the last town to be and the first of the first town to the first of the f server out and the server at t THE DEPOSITE OF THE PARTY OF TH without transfer to the calculate only and allow the ways all and only the while the in the second sale of a period of antical measure with THE STATE OF THE PARTY OF THE P of deciment alone of the property and the second or attraction of the THE PROPERTY AND AND INCOMES THE MALE DOLLARS OF REPORT HOUSE THE PARTY OF THE PARTY HOUSE THE The cold which become that were in the cold to be a second to be a second to be a second to be a second to be a and the matter the manufactured builty white off an empty sometimes com-The tree retre south of the section to lette the purbationist in everyone of appropriate only and otherway To receive the weeken only but and the page of the set i women decreases on the sold and the property of the p MANA THORES AND ARTER OF THE STATE OF THE ST the state of the second production of the second se TITLETEN THE STREET PROPERTY THE STREET THE THE PROPERTY NAMED IN STREET, TOTAL THE SELECTION OF THE SELECTION OF THE PROPERTY O with the final can dearly as your per more as a such party services The same the second of the course dead Agreement and a prince of merchant sale of a life of a county street as as as for an an A STATE OF STATE AND THE POST OF THE PARTY O

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in perticular regions or sites undergo. It often happens that stands on the more exposed slopes or at the upper limits of the type are badly infected, which is a condition bearing more directly on the breakage of the branches and spical portion of the crown by snow and wind than from any peculiarity of the soil or general environment. The funcus fruits quite abundantly on fallen trees.

Fomos pini causes a heart rot in resinous trees, heart rot or sap rot in trees of little or no resin. In early stages the rot is of a reddish color in split section, with small or large white elliptical patches; big, punky, soft brown in cross section. In typical stages the patches become more numerous end the annual rings separate. It is a delignifying rot converting the wood to collulose and is conical in both directions from the area of greatest decay. Oftentimes the rot is patchy throughout the trunk, not uniformly attacking the heartwood.

Fomes laricis (chelky quinine fungus) (fig. 2).

Sporophores perennial, heaf shaped, frequently cylindrical anow white when young with a thin, smooth crust, which later breaks up into a rough brown or gray surface. The flesh is white, soft, friable, and bitter to the taste. Porce small, white, drying yellowish, arranged in layers.

This fungus chiefly confines its activities to yellow pine and larch, but is particularly associated with the latter species in most regions of the Northwest. This latter fact the continue of the contract o

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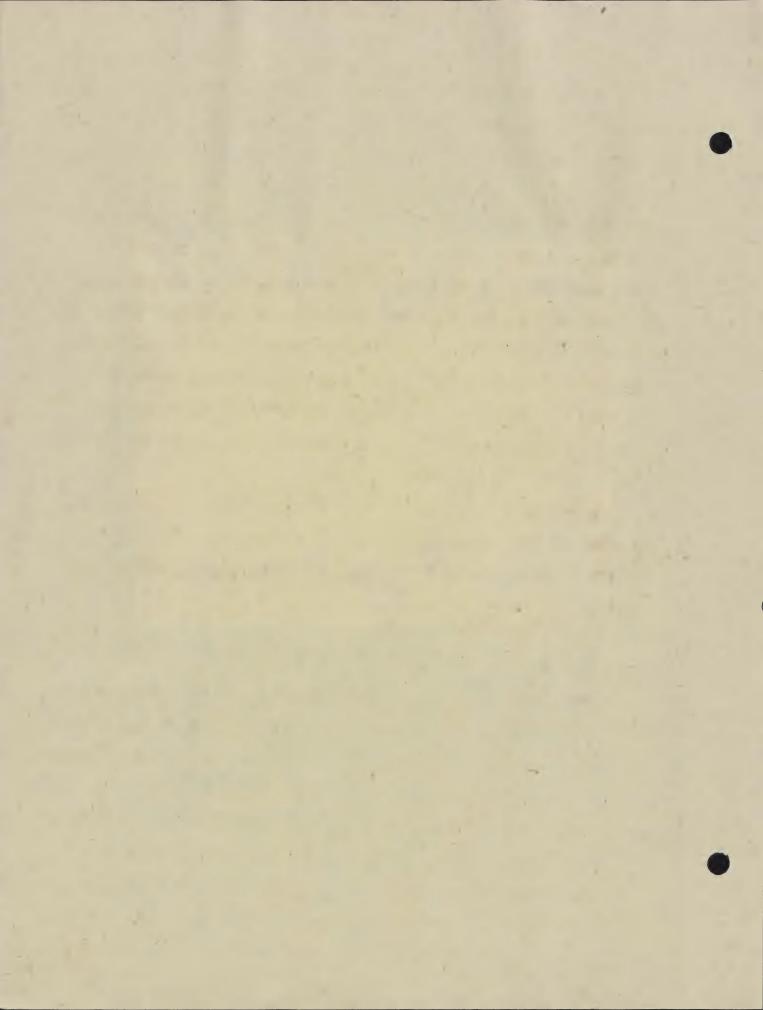
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Fig. 2. Fomes Laricis

Growing from old fire scar

on Larix occidentalis.



tends to promote the spread of the fungus in yellow pine stands wherever this species occurs in sixture with lerch. The fungus usually affects its decay in the upper part of the trunk, and, less frequently, at its base. If entrance is effected at the base the rot usually extends throughout the entire merchantable length. Broken branches and lightning scars are found to be among the causes of entrance in the crown, while fire injury is frequently responsible for infection at the base. Trees attacked by this fungus are usually of an advanced are, noted usually in commection with stands growing on well drained gravelly soils. In narrow canyons and on low flat sites having a mixture of yellow pine, larch and Douglas fir, trees of a younger age class are at soked.

Fomes laries produced a reddish-brown friable heart-ret, breaking up into cubical or rectangular blocks. The ret is similar to that produced by Polyporus Schweinitzii and P. sulphureus.

Pomes pinicola (Red belt Fomes.)

Sporopheres perennial, hard and woody, flat or hoef shaped, upper surface smooth, furrowed gray or black, often with a reddish or yellowish resincus crust; margin rounded, white, yellowish or reddish; context whitish, yellowish or wood colored; pores in distinct layers with circular white to cream colored mouths.

This funcus chiefly attacks the wood of deal trees, but it is also found to be the cause of a heart rot in the base and trunk of living grand fir, larch and hemlock. The fungus produces a uniform carbonizing rot. In early stages the ret

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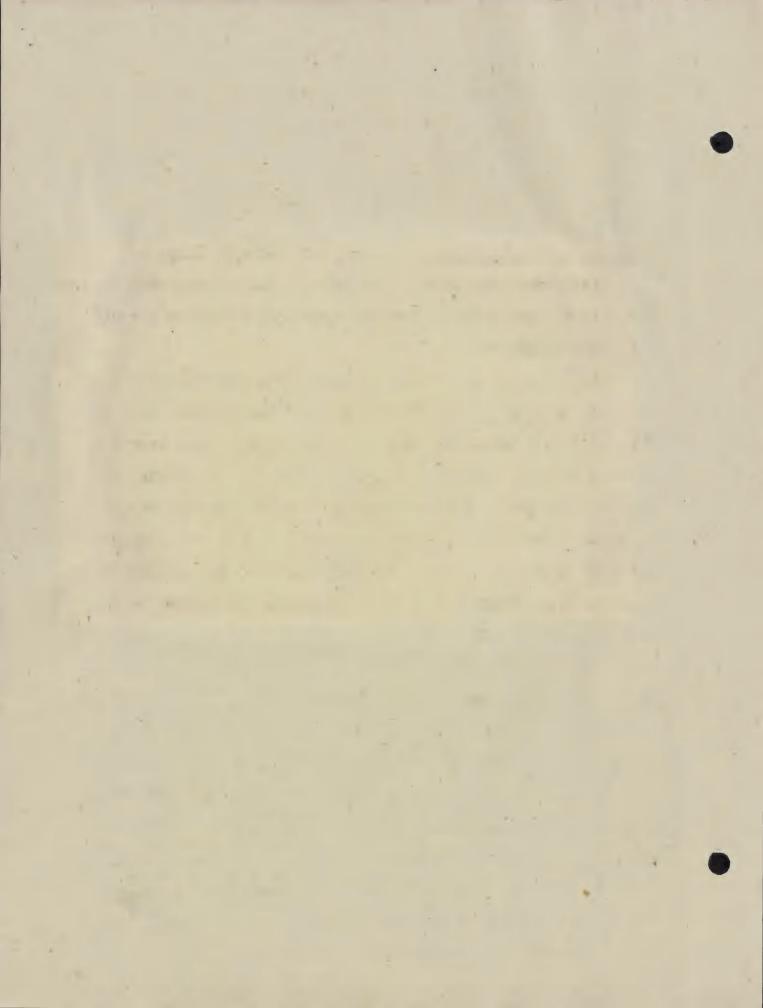
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Fig. 3. Echinodontium tinctorium

Indian paint fungus on Tsuga heterophylla - showing relation of sporophore to internal decay.



is light brown, breaking up into rectangular blocks of varying size, crumbly and brittle when dry, layers of mycelium are formed in checks between the blocks. The type of decay is the same in both coniferous and broad-leaf species.

Rehinodontium tineterium (Indian paint fungus) (fig. 8).

Sporophore perennial, hoof shaped, dark above with concentric growth zones; context brick red; lower surface covered with hard spines when nature.

The Indian paint fungus is responsible for practically all the decay in western hemlock, grand and alpine fir. It is very rarely found on other species. The fungus causes a uniform stringy brown rot of the heartwood. It enters the tree chiefly through branch knots, frost cracks and various mechanical injuries. The sporophores are developed beneath old dead branches and in large numbers. In the absence of sporophores, infection may be detected by the presence of a rusty rod color a half inch or so within the dead branch stubs.

Polyporus sulphureus (sulphur fungus.) (fig. 4.)

Sporophore annual, broad superimposed pilei somewhat stipitate, soft; surface tomentose when young, smooth when old; zonate at times; lemon-yellow to orange, becoming white with age; flesh cheesy-white when fresh, frishle when dry; pores small, sulphur yellow.

The sulphur fungus attacks all our important conifers, but principally larch and yellow pine. It produces an uniform heart rot. In early stages the rot is light brown

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Fig. 4. Polyporus sulphureus on living Larix occidentalis.

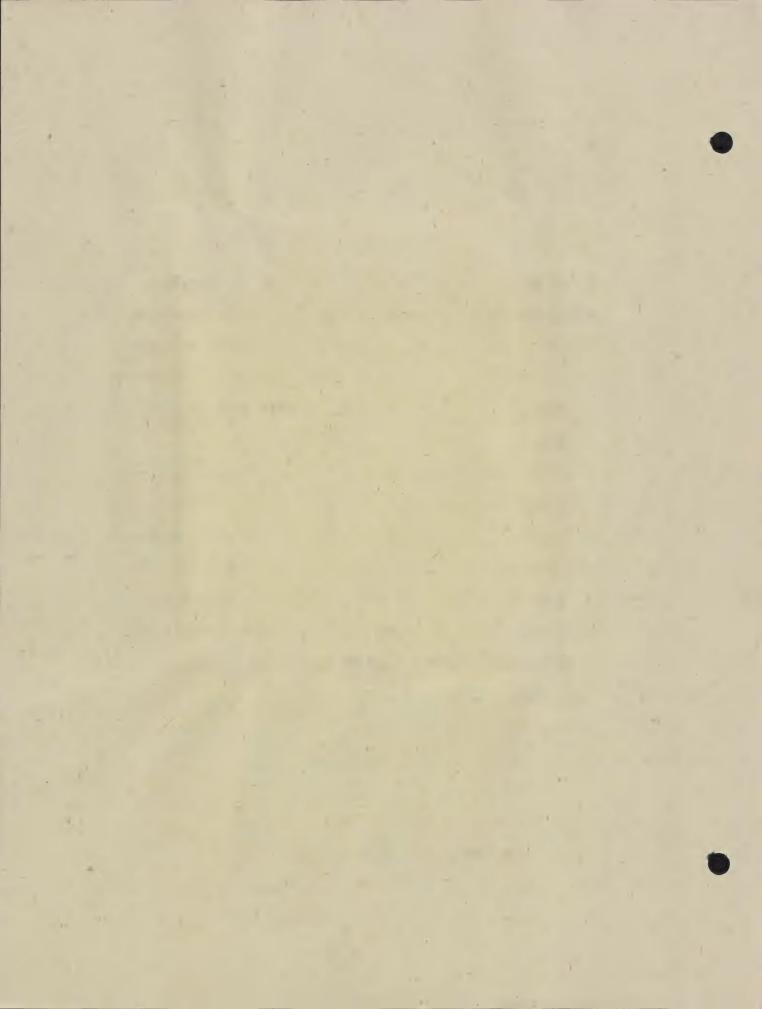




Fig. 5. Pholiota adiposa.

on Abies grandis

growing from a frost crack.



becoming reddish brown, brittle, dry and crumbly with thin felty mycelial masses in the clefts. It is chiefly a butt rot, but infection may occur on other parts of the trunk. The type of decay is the same in both conifers and broad-leaf species.

Pholieta adiposa (Scaly or fatty Pholieta). (fig. 5).

Sperophore annual, mushroom type, usually appearing in dense clusters; surface of cap yellow, sticky when moist, covered with rusty brown scales which disappear with age; stem yellowish, scaly at base, with tufted ring; gills yellowish to brown.

The sealy Pholiota attacks a number of conifers, but is chiefly associated with grand fir and hemlock or with trees with little or no realn in the wood. The fungus produces a uniform conical heart rot. The early stare of the rot is detected by a light yellow stain, the wood later becoming stringy, honey yellow in color with brownish streaks and white felty masses running across the grain, finally breaking up into the separate annual rings.

The fingus is usually found fruiting in great messes from old branch knots and frost cracks.

Rust Fungi:

Cronartium Comandres (Pine-Comandre rust.)

This fungus produces fusiform swellings without modification of the wood on the stems of young, hard or yellow pines The continue of the continue o

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and on the branches of mature trees, rupturing in spring with a mass of yellow blisters full of spores, which are pear-shaped. Alternate stage on Comandra, the bastard tood flax. Very destructive to young yellow pine. Young trees 5-10 years old soon succumb to the attacks of this fungus and the mortality of needlings is often very great in the open forests. The group appearance of the rust is similar to that of the white pine blister rust and is chiefly distinguished from the following species by the shape and rich crange color of its spores when fresh.

Cronsrtium stalactiforma (Pine blister-Castilleja rust).

brush, and rel ted plants, forms but a scarcely distinguishable swelling, without medification of the wood, on branches and trunks of ledgepole pine and yellow pine. The yellow blisters containing the spores project through the bark and are very conspicuous when mature. The fungua is not only destructive to reproduction in the forest but also appears in nurseries.

Cronartium Harknessii (Pine gall-Castilleja rust). (fig.6).

branches and stems of longepole and yellow pine. The wood is strongly modified. Before the stem is completely girtled the branches above the gall are often stimulated to form brooms. This fungus is the cause of the "cat face" cankers so common in longepole stands and is one of the worst enemies of the longepole pine throughout its range. The telial stage of the

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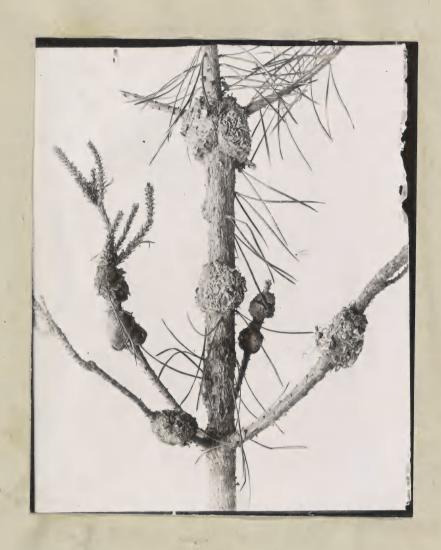
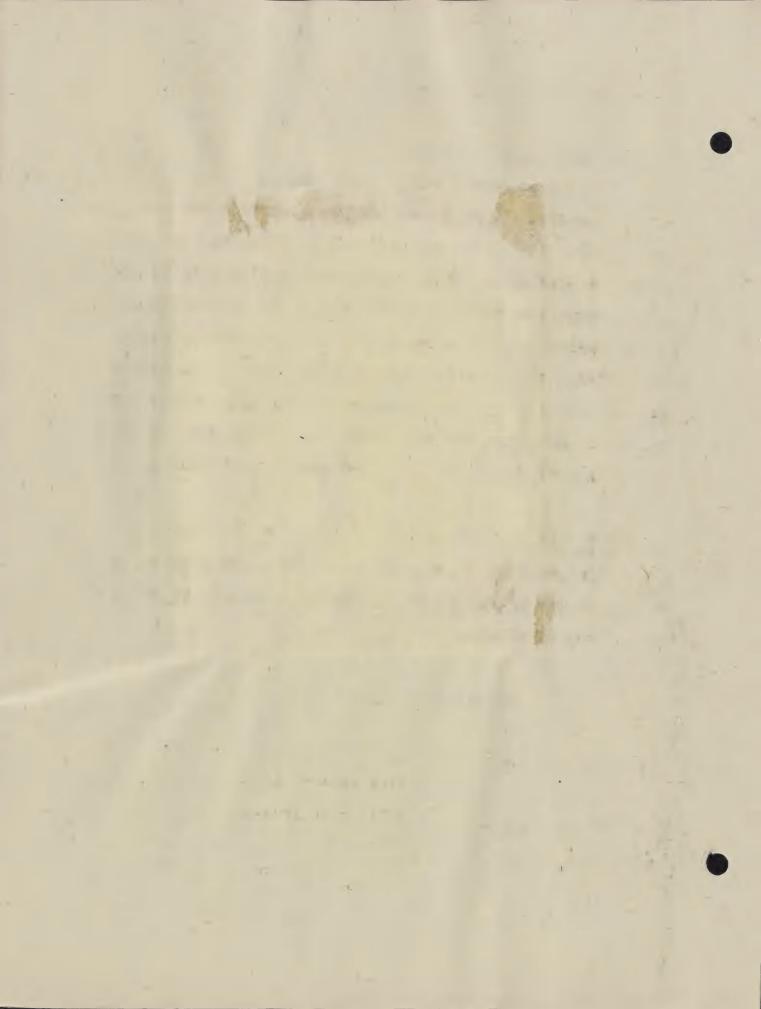


Fig. 6. Cronartium Harknessii.

Pine Gall - Castilleja rust,

Galls - on yellow pine;

Alternate stage on Castilleja species.



fungus is also on species of Castilleja (Indian paint brush.)

Melangacrella elatina (Fir-chickweed rust). (Fig. 7).

This funcus causes comepiencus witches brooms on gram and alpine fir. In the early spring the brooms are conspicutously yellow due to the spore masses produced by the needles. After the production of the spores the meedles fall leaving the brooms bare, and for this reason are easily distinguished from brooms caused by mistletoes. The fungus frequently dwarfs and deforms the terminal shoot of young trees, also causing conkers and swellings on the main trunk of more nature growth, making an entrance for cull fungi. The fungus has its alternate stage on the common chickwood and related plants.

Helampsorella coloradense (pruce-chickweed rust).

This fungus is similar to the shove named species, producing brooms on apruce and having its alternate stage on the same group of plants.

Fungi attacking the Fruit.

Welampsoropsis pyrolae (Spruce cone rust.)

Causes a disease of the sporophylls, shriveling the cones and reducing the quantity and quality of seed. Alternate stage on Pyrola species.

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Fig. 7. Melampsorella elatina.

Fir - chickweed rust,
Forming witches broom on
Abies grandis.

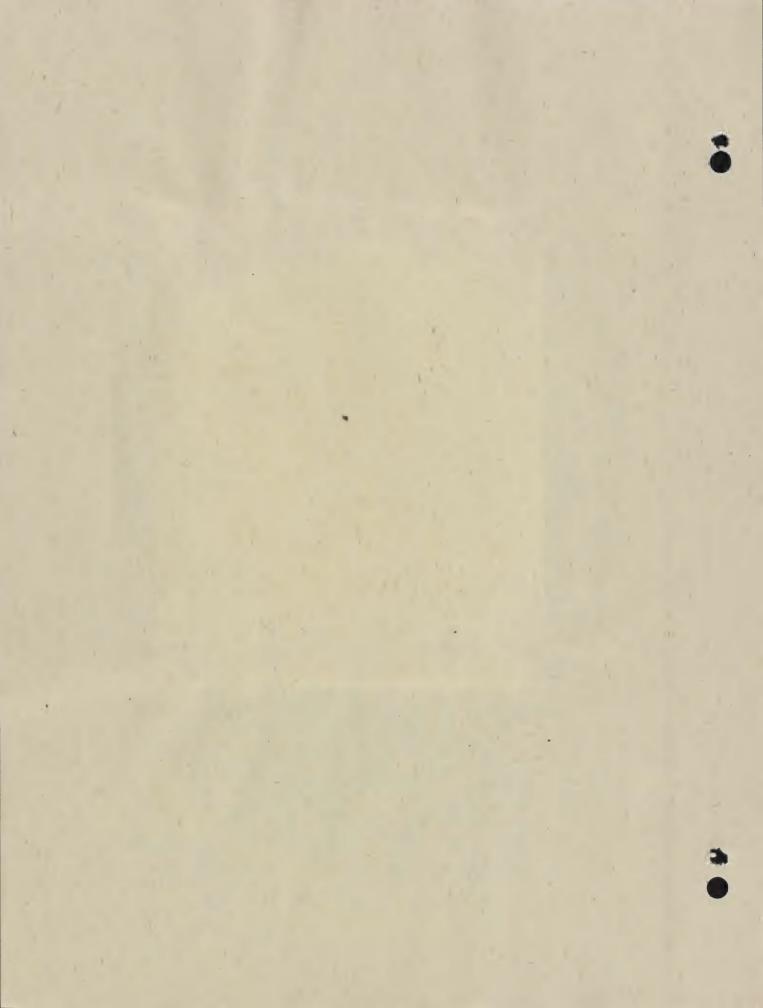
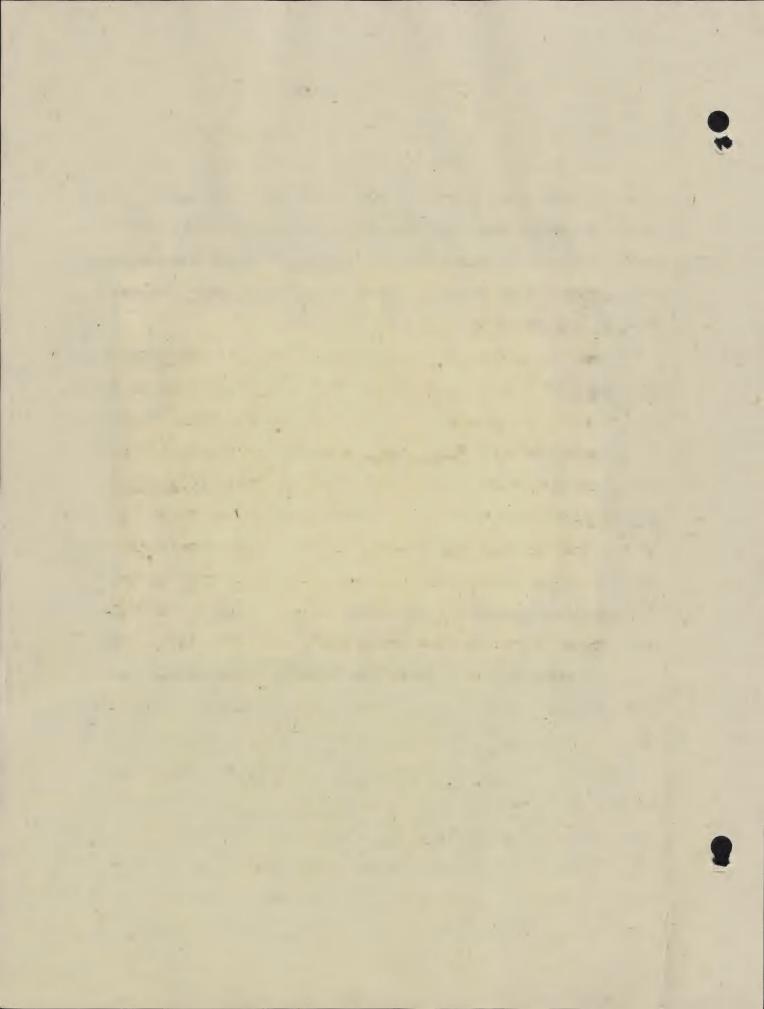




Fig. 8. Polyporus Schweinitzii.

(Velvet top fungus)

Growing out from roots of Western White Pine.



Fungi Attacking the Roots.

Polyporus Schweinitzii (Velvet top fungus.) (fig.8.)

sporophores amual. with stipe, dark brown, valvety or covered with stiff hairs; flesh brown, soft and spongy when fresh, brittle when dry; the stipe is usually short and thick, and in most cases excentrically attached, sometimes wanting when growing from trunks. Pores large when young, becoming longer, irregular and laserate when old.

From the standpoint of rapid loss in vitality Polyporus Schweinitzii Fr. is probably as much to be feared as an enemy of our valuable species as any other fungus. Often working in ecoperation with Fomes pini, a rapid destruction of all merchantable parts of the trees soon results. Polyporus Schweinitsii enters its host either through wounds at the base of the tree or directly attacks the roots not previously injured. After traversing the more superficial root system. the mycelium enters the heartwood of the trunk causing the well known "butt" or "red brown rot". Isolated infections are very rarely found; where one tree is infected its neighbers in most cases will likewise become diseased. The root systems of trees in a crowded stand are usually in contact, or. as in some cases, in physiological connection. Spreading in the heartwood of infected roots the fungus is enabled to encompass many trees in a comparatively short time. The rot seldom extends upward in the trunk more than the first log length, five to eight feet is the usual average. Since the fungus travels through the soil and does not always fruit,

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its presence in the stand is hard to detect and is still more difficult to combat. In logaing operations great care should be taken to extend the outting areas areund clumps of trees infected with this funcia. If the pathological survey of a proposed sale shows that clumps of infected trees stand on the boundary of the seles area they should be included in the sale. If the brush is piled and burned, as many piles as is convenient should be made on stumps of infected trees in order to burn the roots as far into the earth as possible. Fire injury to parts of trees above ground may not be a means of entrance by this funcia, hence it is not likely to become prevalent in those trees left standing on an area where fire has been employed. Stops should be taken, however, to eradicate all the infected trees on the sales area. B. fen T. F. b. 1950 - (Y. XXIY H.)

Sporophore annual, mushwoom type, honey colored but yearying in color to brown; upper surface marked with tufts of brownish hairs, especially at center, and with scales; margin of pileus often striste, stom stout, tall, whitish, yellowish or brownish, smooth or scaly, with a conspicuous ring; gills whitish or yellowish. Produces an abundant mycelium forming fan-shaped sheets under the bark, later breaking up to form shiny dark strands or rhisomorphs. The mycelium penetrates the cambium layer, a tacking the living cells and girdles the tree.

The universal occurrence of this fungus in the forests of the Northwest is of serious consequence and must be taken

The resolution of the state of

April Business Come of the Committee of

tendent alle active actives a visitation of the control of the con

an already with the name of all the countries of Labourers and the

into account in the cilvical projects for many regions. The fungus is easily recognized by its habit of growing in clumps about the base of the infected tree, its conspicuous honey colored pilei when young, turning yellowish-brown when old. By removing the bark from the base of infected trees, the white palmete apreading myoelium which is so typical of this fungus, is generally exposed and is an infallible means of determining the funcus. The funcus is further characterized by its habit of producing rhimmorphs, cylindrical or ribbon-like strands of mycelium which ramify into all directions between the bark and wood of living trees. These rhizomorphs extend into the earth, oproad to adjacent trees, and is a most effective egent in extensing the disease. After the destruction of the cambium the mycelium begins to attack the wood, particularly the parenchyms of the resin canals. The dostruction of these cells produces an abnormal resin flow, both within and without the bark, comenting the soil about the base of the tree in a most characteristic manner, Within a comperatively short time after the fungus girdles the tree and the flow of resin appears, or even before, the tree dies.

The fungue attacks all age classes, but is particularly common on young growth. The rapidity with which young four to fifteen-year-old trees succumb to the attack of this fungue after they have made an excellent growth for the year, is common observation in the early autumn in many old cuttings and in the forest fire areas. The infected trees yellow-up and die quickly, by which this type of injury may be readily distinguished from the long period of sickly growth following

investment of the rest of the form the state of the section and secure at animals to obtain but of purious of pitture at support escid acceptable of the totales the time the theory and the Colta man emportant parties of the best of the same and salle fewering of a first of the same of the . In 1807 Will to Isolott be at John called to get wise a current as at the color of the second will the property of at the following the second of the World of the transfer and the state of the country of the of recording abtremental or Testacuttes . estrumperate materials Ero, and provided sunthannia Lie gint galorer dotte ter franch mil othe mosts sibreach lift and the agent Molect to Some the durals and content content and and among femilian and another, direct the action the conficulties but and any in the section of the contraction of ers enterior race , hour day describe of ord pastence of motor ville and the cold of the cold of the cold of the cold of the distribution that is the property of the second of the second the series and another than the control of the property of the the court of the grant continues in medical promote the delication of the the sea one mener to work and bentones for antitud and and and and

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wintered the many of matter give, and he addressed not be supply and the supply of the second second second

an attack of insects or from the effects of drought.

The activities of Armillaria melles does not end with the death of the host, but continues to fruit about the base of the tree or stump as long as there is sound wood remaining. The reason have the ability to remain viable under the bark and for this reason the fungus will be extremely hard to eradicate and explains its presence in areas swept by fire. The fungus, however, may be killed in the forest soil away from the base of stumps or trees by severe ground fires, since the rhisomorphs colden develop more than two to six inches under the soil. These atrands may follow roots of trees to a much greater depth, and a fire may not have much effect on them unless the stump is entirely consumed.

Fomes annosus (Boot Fomes.) (fig.9.)

The sporophere is woody, usually thin and irregular in outline, with a smooth, brown crust, and is perennial; the context is white or pale yellowish; pores small and round, conspicuously stratified, white to yellowish.

this is a root fungus cousing considerably more samage in our western forests than was formerly supposed. The fungus is difficult to detect, owing to the fact that the approphoses are usually produced deep in the root spur and are frequently covered with the forest debris. The mycelium produces a red rot, leter delignifying the surmer wood, which usually in badly infected specimens includes the entire heartwood of the base of the tree, often extending upward for several feet. The fungus apreads either by direct contact of the roots of neigh-

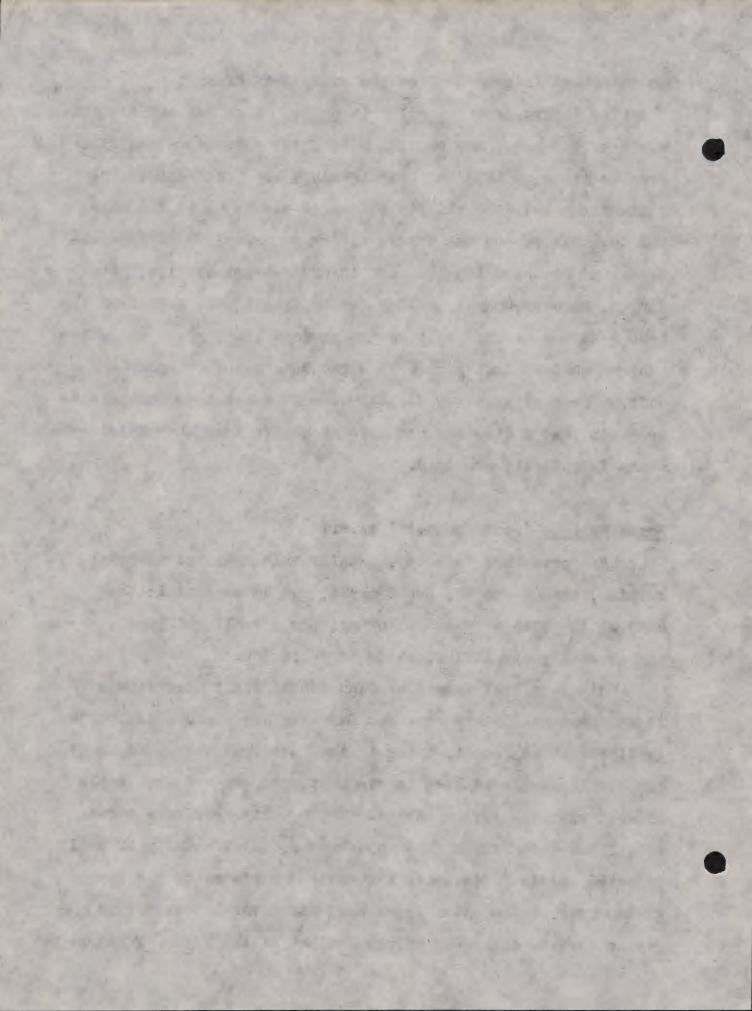


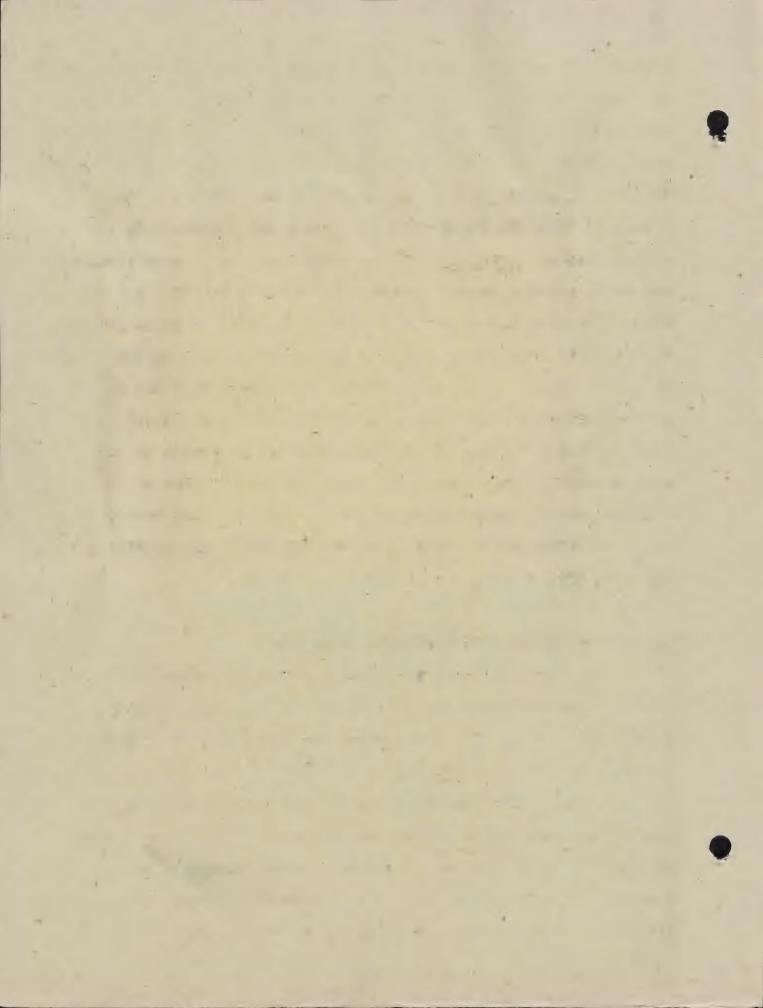


Fig. 9. Fomes annosus.

(Root fomes)

Sporophores from roots of

Western White Pine.



boring trees or by meens of spores. As in the case of Aratilaria mallen a flow of regin to produced from the infected parts, but the subscritcal sysclius of Pomos annosus may be readily distinguiabed from that of the former by its prestor delicity and thiny whiteness. Young, so well as old, trees are attacked. The functo is found in 30-50 year old stands and coorsichally on younger trees. Force among her been found to be note shundant and works greater injury wherever the trees occur in pure stands, especially when the stand is overstocked. This is directly due to the close relation of the root system which enubles the fungua to oproad from one tree to another. The fungue does not occur as abundantly in mixed stands of white pine, larch, coder, with a sprinkling of birch, alter, etc., neither in stands on the more mineral coils. Thits pine stends first in or er of hosts infected, hence the presence of other souliers, also hard woods which are likewise attacked, prevents the close accounties of the root systems of trees of the seme species.

Poris Weirii(Brown cedar Poris). (Fig. 10.)

or standing trees, or spreads along the underside of fullentrunks. Always inconspictous.

The brown coder Peris is chiefly responsible for the prevailing butt not in western red coder and is the chief energy of this ratuable species. Trees of a comparatively young age class are affected. In dense pure stands this fungus is particularly destructive. Its species senetimes grown through

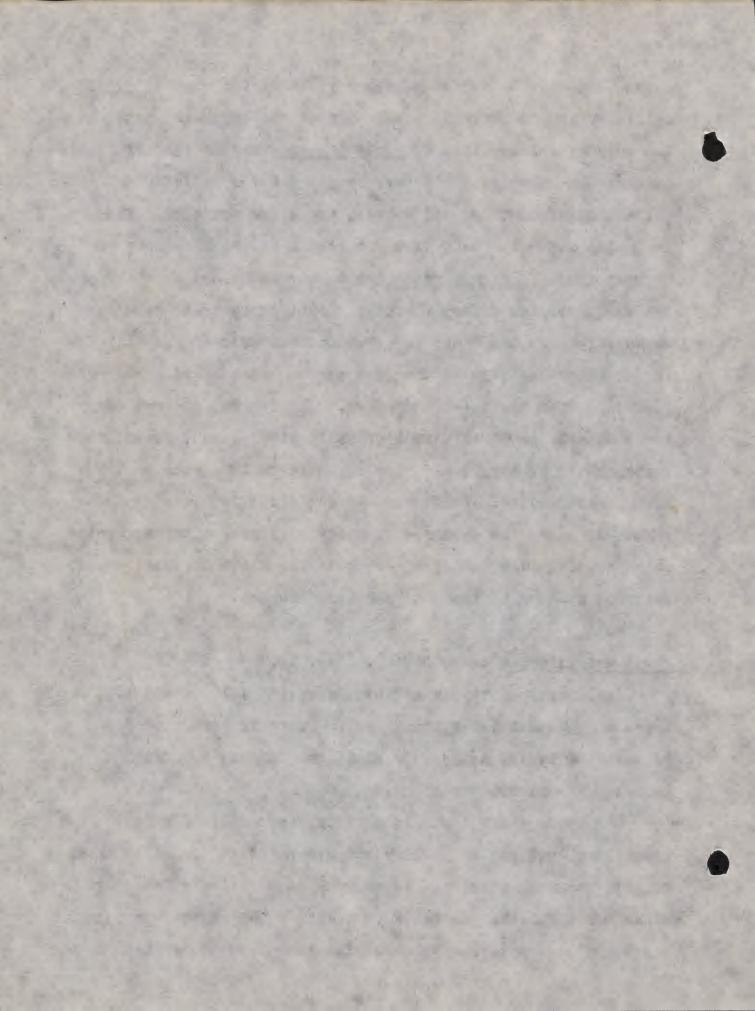
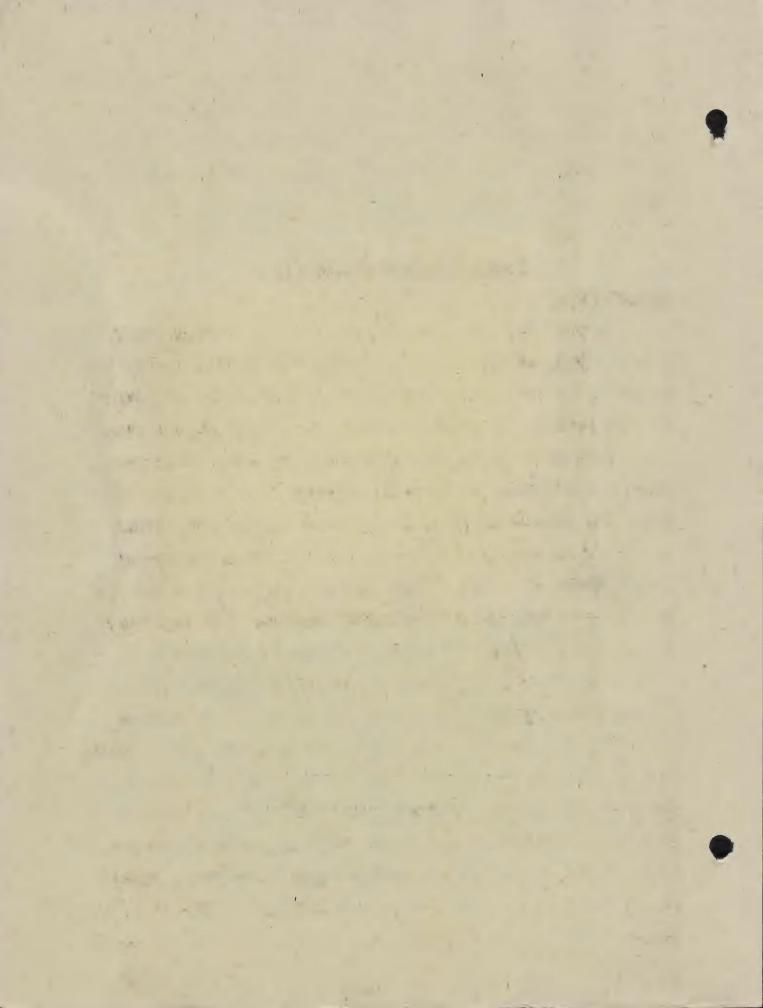




Fig. 10. Poria Weirii (Brown cedar poria)

causes butt rot in Western red
cedar

Thuja plicata.



the forest mold, matting it into hugh layers, and by this means increases the original tree of infection. The fungua couses a pellowish-white laminated not which may extend for a considerable distance in the heartwood, varying with the age of the tree.

Funct attacking the Hardlen.

Persony content

The next important models forgue of the meetern white pine is <u>logisderaium pinestri</u> (models cost fungue) and is the cause of the extensive browning of the meedles of this tree in many regions of morthern Naho. The fungue plays a premiment part is heatening the suppression of trees in mature forcess. Sometimes it takes on epidemic tendencies and attacks the meedles of trees if all ages. White pine stands in moderately deep revines uniformly turn brown and openar from a distance as if so rehed by fire. The disease has also very meantly appeared in the forest nursery. It is a very assently appeared in the forest nursery. It is a very assent success of death of young meedlings in the forest.

Lophodernium norvisequium (naedle nerve fongus) cousing defoliation of croad and sipine fir, Symposermella lariois (larch
leaf omet), causes a serious defoliation of vestern larch in
dense stando; <u>Keithia thujima</u> (ceder Keithia) is a serious defoliator of vesterored ceder, sometimes cylinnic on young seedlince in the ferest; <u>Hyposerme (cformana</u> (pine broom fungus)
causes large conspicuous brooms on yellow pine; Insciding infesterer (fir loaf cout fangus) is sometimes destructive to the

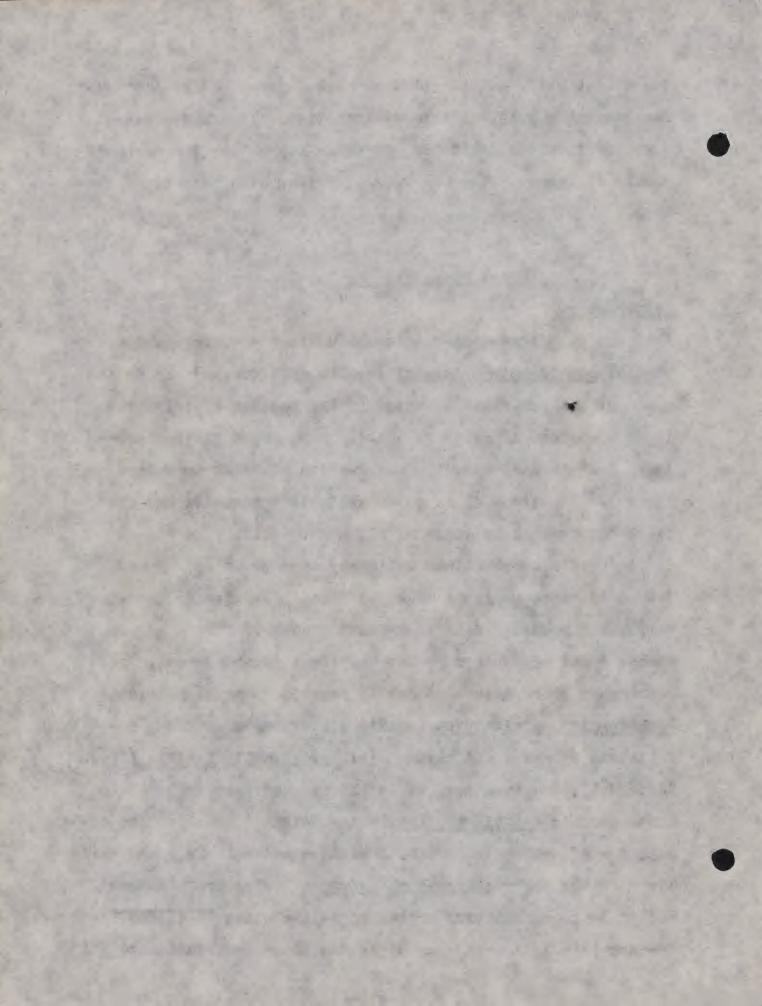




Fig. 11. Witches brooms.

on

Larix occidentalis caused by Rasoumofskya laricis.

The supplier of a section of a water the THE RESERVE TO A PROPERTY OF THE PARTY OF TH CONTRACTOR OF THE PARTY OF THE THE WALL STREET the same of the sa \$ - THE ST. 1. 2 - 1911

leaves of fire; <u>Rerotrichs mirrs</u> (black cobweb fungus), and <u>Recreatis contains</u> (pine cobweb fungus), are common in alpine regions, the ferror usually on besides and fir, the latter on pine, but are relatively unimportant except in the case of nurseries attacted at high elevations.

Dants:

Malongoorn albertonsis (Dougles fir-popler rest), E. med-MER (Larch-popler rest), Colsosporium moliderinis (pine-golden rot rust), are common forest tree susts in our region, but rather unimportant in the forest, but sould be serious in the sureery.

There are many other twig and models blights of conferous treas, but they are more or less transitory and should not be greatly foured. Extreme weather conditions are often responsibills for the browning up of the needles of confere. Succeeditions may result in corious oppoliontions, with semi-peresitio function increase, but injury of this nature usually disappears on the return of normal matther.

3. Diseases caused by Phaneroganto Plants, Mictletees.

Mistletoes injury to coniferent trees in corthocators forests to secretaes a substance as to secure in some regions the nature of a serious ferent problem. The most common mistletoes and the boots on which they are found are Resourcefully larious, (the larch mistletoe) (fig.11), 2, gamplepois, (Feeific ocean yellow pine mistletoe) (fig.12), 2, gamplepois, (Leópepole pine mistletoe), E. joughasii, (Bourles fir mistletoe) (fig. 13), 2, gamplepois, (small white pine mistletoe), also on limber and white bark pine, 2,

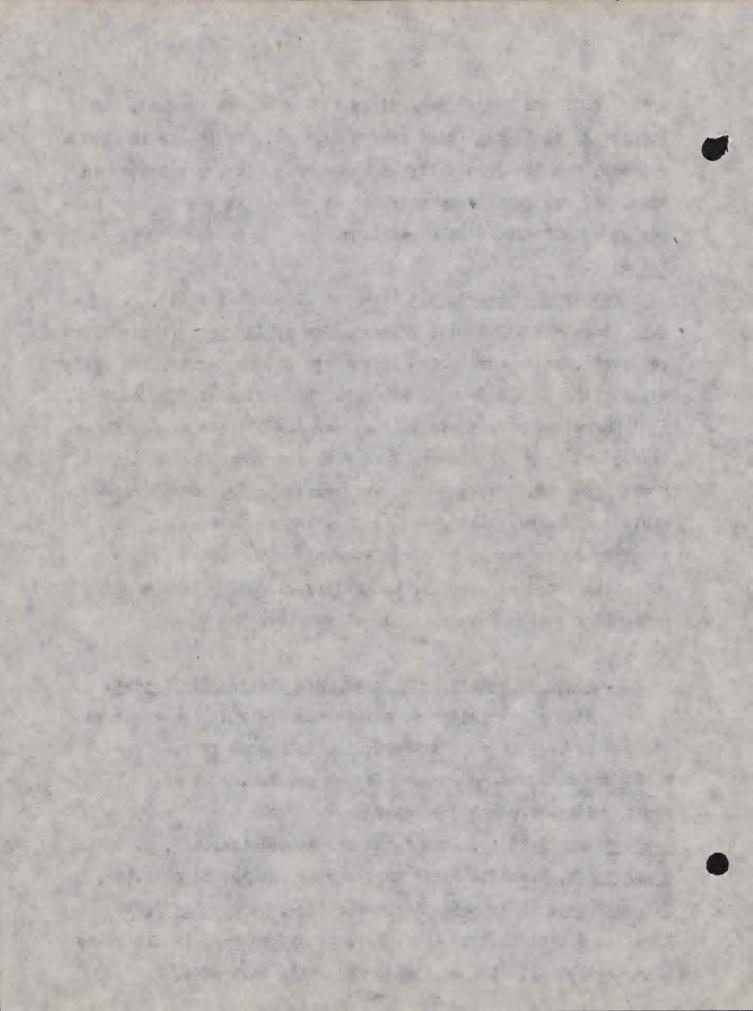




Fig. 12. Female plant of

Razoumofskya compylopoda,

the yellow pine mistletoe.

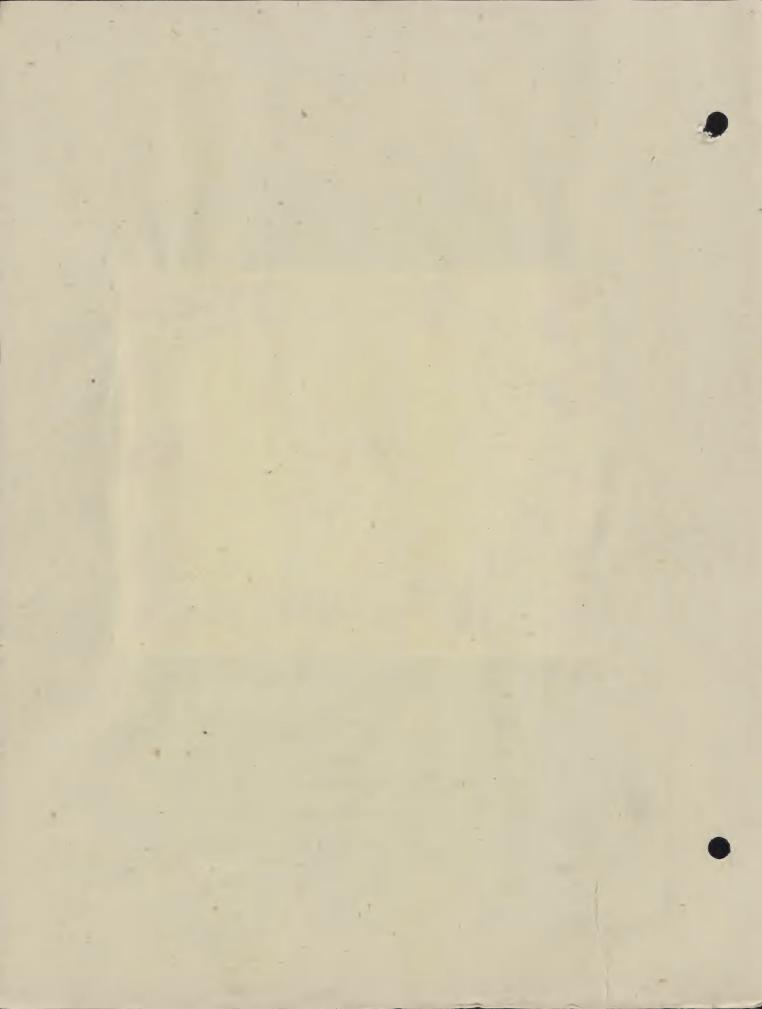
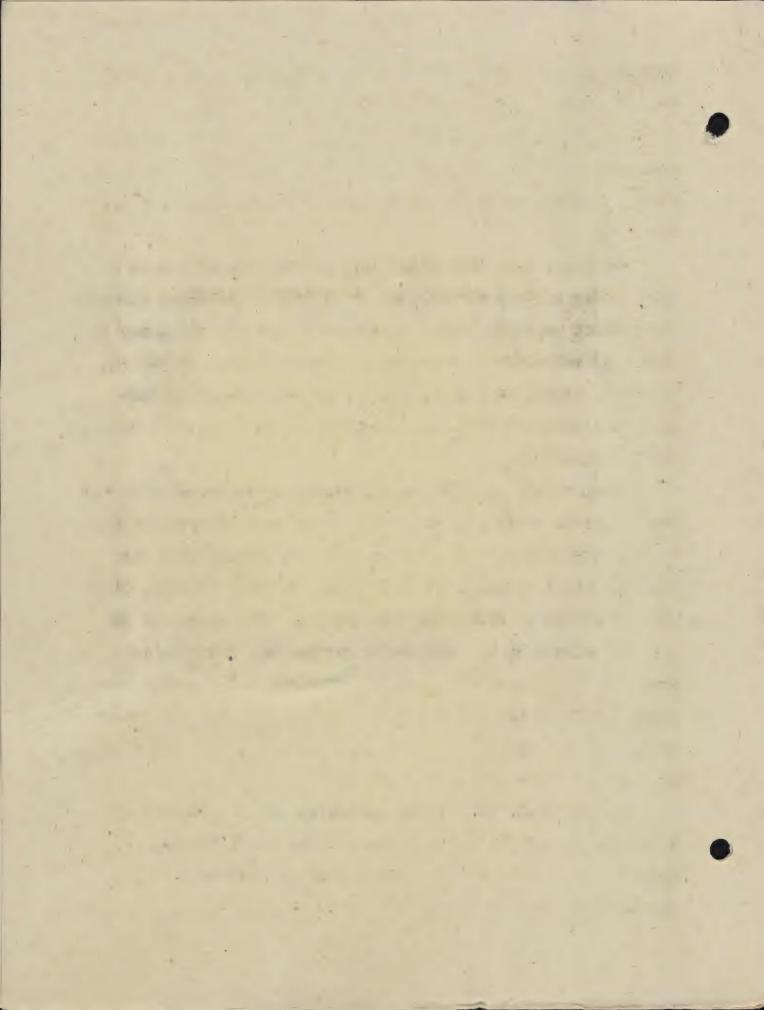




Fig. 13. Witches brooms on

Pseudotsuga taxifolia

Razoumofskya douglasii.



tenegrate. (hemlook mistletoe), and i. gooidentaling abletime. on fire (large leafless mistletoe of fir.)

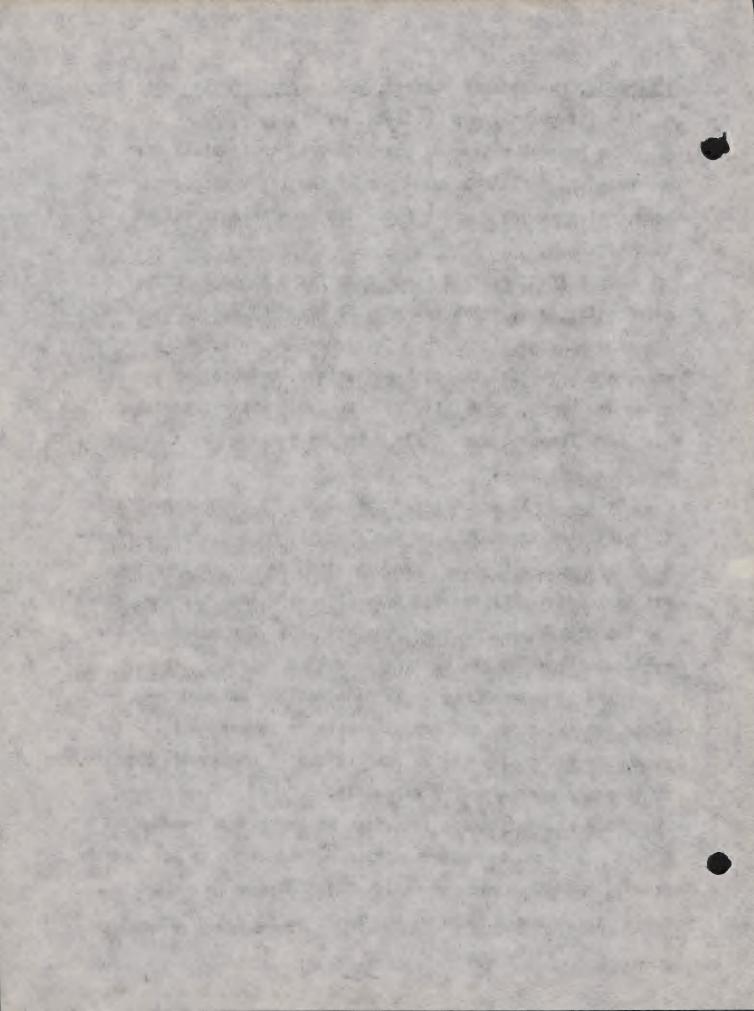
The general nature of the injury by these mistletoes is expressed in a gradual reduction of the leaf surface of the host, which causes a great reduction of growth in height and disseter.

Her infections take place only through the access of a germinating seed, which reaches the point of infection through the natural expelling force of the seed capsule, which may be made sere effective in point of distance traveled by the mid of strong winds, by falling from branches above after they have been loosened from tests original resting place by rains, and by animal life.

Trees of all ego classes are liable to infection provided the mistletce seads full on parts of the host not yet protected by the anture cortex. The parasite may appeal from the critical point of infection into older cortical tissues, which are not liable to infection from sit out. The spread of the certical strong in the reverse direction from the line of growth of the branch may continue watil the outer cortex because too thick for the serial shoots to penetrate it. After this, the certical roots become suppressed and eventually die, or they may become wholly parasitie.

Exceptive mistletce infection of the lower branches of a tree may cause the upper portion of the grown to die, giving rise to the phonomenon commonly called stagment or spiketop.

Hevere infection throughout the entire your often results in



the South of the tree. Tours execlings from S to 6 years old ore often killed within a concerntively chart time often in-

infection on the process is practically all cases consess the forestion of large brooms, which mericusly interfere with the life function of the tree. The same is true in the case of infection as the true, thereby buris are forest.

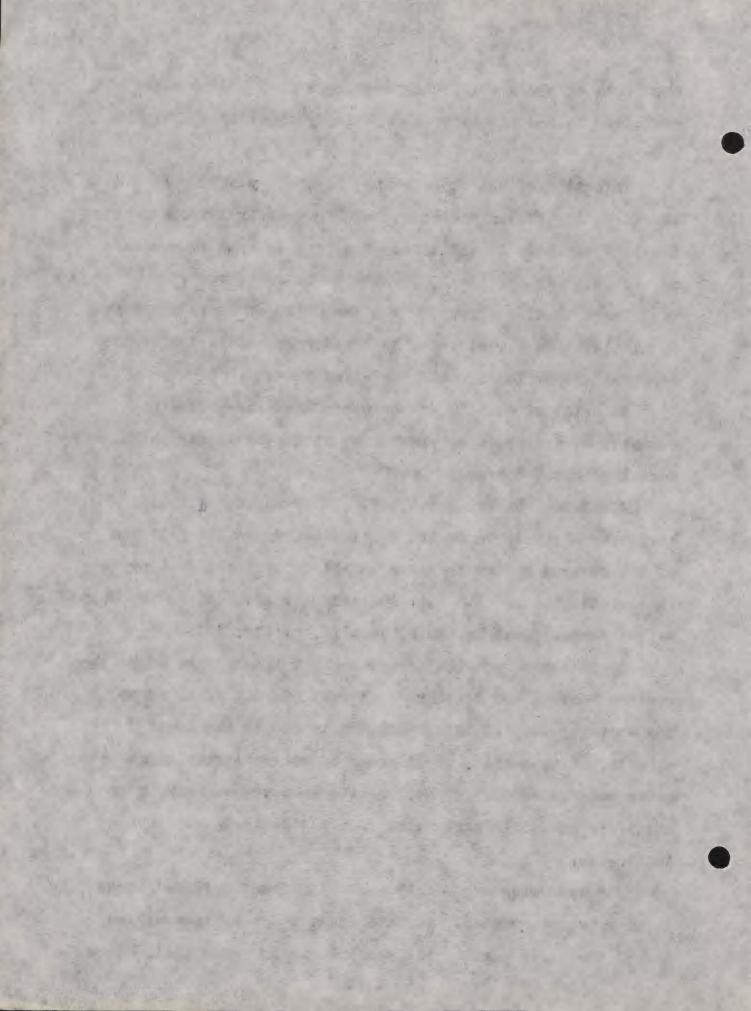
by michietoe on forest trees in often responsible for serious seprelations by Yangi and forest-tree insects.

In point of quality and quantity the coad-producing capacity of the trees suppressed by mistletce in far below that of normal wainfeated trees.

Mistletce can be controlled. It is exceeded that a beginning may be code in its cradication or in the relaction of the reverse caused by those parecites by working along the lines insteaded in U.S.B.A. Bulletin Sc. 360, cod in the Journal of Agricultural Research, Vol. 12, p. 718, 1918.

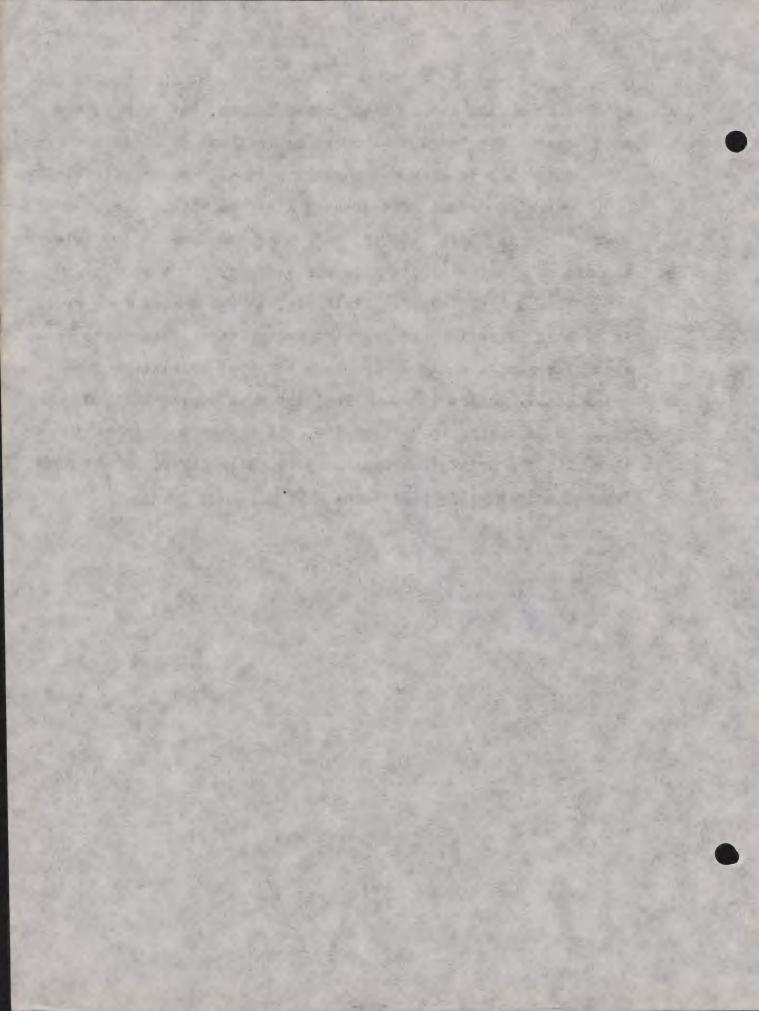
restorn Mentana and surthern Diebo are heavily affected by wood-rotting fongi. This condition is due to the hazid climate, denne stands, great areas of virgin timber which have never been spier emagement, and the presence of healock and walte fir and white pine which seem particularly prodices and to limate.

The sporopheres of wood-testroping funct produce appress
in exorecus constitios. Certain funct which produce appress
foring the early part of the sesson usually renew their spore



production during the fall and reiny season, and some of the most destructive fungi show extreme hardiness in that they are frequently able to grow and sportlate in mild weather in winter.

stands than in denser timber, but since the foreste are drier because of greater atsospheric circulation, the effect is seconds to conterbalanced. Similarly, though speres from trees in exposed situations are carried much farther than these from alose forests, the ferror are less affected by virtue of the drier sites. Below is summarized the most important tree diseases occurring in this region, which when used in conjunction with the brief descriptions previously given, may be used for purposes of identification.



Host Index for the Principal Pungi and Mistletoes.

of Northwentern Semifers,

or District One.

Formes pini (Ring scale fungus)

Polyporus Schweinitzii (Velvet-top fungus)

Formes annusus (Root Formes)

Armillaria melles (Roney mushroom)

Lophodermium pinastri (Reedle cast fungus)

Western Yellow Fine

Pomes pini

Rypoderma defermans (Pine broom fungus)

Polyporus Schweinitzii

Fomes laricis (Chalky quinine fungus)

Cronartium Harknessii (Pine gall-Castilleja rust)

Cronartium Comandrae (Pine-Comandra rust)

Cronartium stalactiforme (Pine-Distor-Castilleje rust)

Rascumofskya campylopeda (Pacific Comat Yellow Pine mistletoe).

Todgepole Pine
Coleosporium solidaginis (Sestern pine-selden rod rust)
Fomes Pini
Polyporus Schweinstzii
Cronartium Harknessii
Cronartium Comandrae
Gronartium stalactiforme
Heopeokia Coulteri (Pine cobweb fungus)
Hascumofakya amaricana (Todgepole pine mistletce)

Testern Larch

Fomes pini

Fomes loricis

Fomes pinicola (Red belt Fomes)

Hypodermella Laricis (Larch leaf cast)

Folyporus Schweinitzii

Melampaora medusas (Larch-copler rust)

Rasoumofskys Laricis (Lerch cistletce)

Pougles fir

Yolyporus Johnsinitsii

Pomes pini

Polyporus sukohureus (alphur fungus)

Assoumofelya douglasii (Deuglas fir mistletee)

Welsmpsora albertensis (Douglas fir-coplar rust.

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 Fones pini
Fones pini
Fones annesus
Polyporus Schweinitzii
Helampsorella elatina (Fir-chickweei)
Melampsorella coloradensa (pruse-chickweed rust)
Nelampsorella pyroles (pruce cone rust.)

Festern Red Cedar

Foria Feirii (Brown cedar Feria)

Folyporus Schweinitzii

Fomes pini

Feithia thujina (Cedar Keithia)

Western Hemlock, Fountain Semlock
Echinodontium tinctorium (Indian paint fungus)
Fomes annosus
Fomes pinicola
Herpotrichis nigra (Black cobweb fungus)
Pholiota adiposa (Boaly or fatty Pholiota)
Rascumofakya tsugensis (Bemlock mistletca)

Grand and alpins Fir
Echinodontium tinetorium (Indian paint fungus)
Fomes annosus
Fomes pinicela
Lephodermium nervisaquium (Neoale nerve fungus)
Phacicium infestans (Fir leaf cast fungus)
Fholiota adiposa
Rassumofakya cosidentalis abietina

White bark and Limber pine Most of the common word destroyers and Razoumofekya cyanocarps (large white pine mistletce).

Practicel Considerations on the Control of Disease in the Porent.

The saving of money in the operation of Mational Forests can be compared to the various nethods of exomeny applied to any business. There are many ways in which this economy can be practical on Mational Forests in respect to the part which forest pathology plays in their administration. Among the more important points simed at better economics and direct

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saving the following may be mentioned, as proposed and demonstrated by the Forest Pathologist in this District: (1) Prevention of direct less by proper protection from disease of forest nurseries, plantations, and, hence, to the forest; (2) Prevention of agreed of discusse by proper timber cale regulation: (3) Prevention of financial loss in operations by more nearly accurate timber surveys and later stumpage estimates of proposed sale areas: (4) Provention of loss in stands due to rot by timely pathological surveys and the application of proper cutting ages to stan a of timber which deteriorate in value after a certain period is passed due to increasing amount of rot in the stand: (5) Prevention of less by windfall of seed trees and seed tree groups through rotting of roots and basal parts of the tree; (6) Direct saving in securate judgment in scaling infested logs on sole areas; (7) Direct saving in close utilisation of forest materials on sale areas, especially culled moterial caused by ret, and the possible utilisation as byproducts of all funcous infected material left over.

(1) The prevention of direct loss and subsequent finencial loss by employing proper protective measures against diseases in forest nursery plantations, thus retarding the progress of disease in native stands of timber, is a first prerequisite.

Prevention of future losses in seedlings, transplants, and merchantable timber is just as important, if not more so, than the salvaging of material partially lost by the attack of forest tree diseases. It is the air of the forest planter to restore a certain demaded or burned-over area with suitable seedlings

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 at a minimus cost. This cost can be appreciably affected by the initial cost per thousand of raising these sandlines from the time of sowing to the time of transplanting in the plantation areas. The losces tue to fungus attacks have considerable offeet upon increasing the cost of these seedlings. Often entire beds of first-year seedlings are destroyed by fungous attack, and the ontire cost of seed collection, oterace, seed bed preparation. sowing, etc., is lost at once. Proper methods of prevention could save this less or, at lesst, reduce it to a minimum. The collection of seeds having a high percentage of sermination end from trees free from disease, improving sites for seed beds, removal of courses of infection in the vicinity of the nursery, a strict policy that all seedlines brought to the nursery from other sections of the country be free from disease, supplying the physiological requirements of the seedlings in the seed beds, and the direct application of fungicises to inhibit damping-off fungi, are some of the control measures to consider in growing socdlings.

economic loss from disease becomes more difficult. Our virgin forests are very irregular in point of ago class, density and mixture of species, and disease has run rife from the besimning unchacked. To make a beginning, data on loss through domy and other causes sust be assembled. For example, the estimated loss in ventern white pine in this region due to rot by fingi equals 37,201,250. This computation is based on actual data taken on nine sale areas. The ecterioration of stands of

The territories of the control of th

western bemlock and grand fir in the Morthwest represents an onormous less from an economic standpoint. Bany stands are found infected and in which individual trees run from 10 to 80 per cent in rot volume. Such stands usually represent a total loss, since logging such a reus would be highly uneconomical. If loosed before the rot percent became too high, it might have paid in conjunction with the felling of other species in the stant; but only a pathological survey at the proper time could have aided in establishing this point. This shows the necessity of determining the factors that will inhibit less. Determine what accodes are inferior in point of susceptibility to discose, and by their gradual removal or discouragement in . the general plan begin to bring about a reduction of the agents of infection. The technical application of the knowledge thus gained as regards these, as well as other more desirable species, will make it possible to balance loss data against increment and will lead to a proper appreciation of the relation of disease to silvicultaro.

The prevention of the s read of forest tree diseases by the enforcement of proper timber cale regulations is an important ant dector toward economic saving and should be at once put into effect after the importance of the role of forest tree diseases in forest management is realized. Prevention of epidemics of forest tree diseases which threater to destroy large areas of reproduction can safely be classed as definite savings in so many dellars and cents. Puture valuation formulas are applied in cases where trespens by fire has wiped out large areas of valuable seedlings and yours growth. There is no reason why

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such a formula could not be applied to areas threatened by destruction through fungous diseases or by mistletoe. If preventive mehtods shall have been ouncessful in saving the crop, then the loss based on future valuation prevented can truly be called a neving. Sale regulations by enfercing the destruction of all infected standing and down material can insure a healthy crop of reproduction and can materially reduce the apread of disease.

- by more nearly ascurate estimates of the sound contents of the stand is one of the factors considered as a direct saving in dollars and cents. This not only shows the necessity of giving proper consideration to the determination of cull due to rot to any given stand, but results in the accumulation of cull data of value in establishing cutting rotations.
- (4) Theely pethological surveys and a resultant application of the proper autting are to a stand which, due to the increasing amount of rot, is liable to deteriorate in value, are important in an effort to learn the status of health of a forest. Such work is also important from a dollar and cents basis. This phase of work has only been recently proposed by the Forest Pathological and is the first work of the kind proposed in this country. If the sutting age of a stand can be determined beforehand so as to eliminate so far as possible the chances of cutting the stand when the rot has progressed so far as to make the logging operation a loss, then the resulting saving will be wort the effort and the coat of a pathological survey of the

- Sale Sale And Control of the Sale of SELECTION ASSESSMENT TO MAKE THE WAS A PROPERTY OF THE PROPERT CONTRACTOR OF THE PROPERTY OF THE PARTY OF T and appear have been also and defect the control as the law we have 2000年 1000年 CATTER SET SERVICE TO SERVICE THE RESERVE OF THE PARTY OF a cannot be object to the second of the seco 是我是我们的一个时间就是一个一个大型的一个大型的一个大型的一个大型的一个大型的一个大型的 A TELESCOPE OF STREET CO. L. C. L. C AND STATE OF THE DESCRIPTION OF THE PROPERTY O 工工工作工作。 网络大线 医多种 医多种 医多种 医多种性 医多种性 医多种性 医多种性 医多种性 AND THE PARTY AN to a will a light to the fire of the analysis of the second of the secon 为此之外的影响,但是自然的影响,但是一种是一个是一种是一种一种是一种是一种人的。 电电影电影 中国社会学 SHOULD BE WITH THE REAL PROPERTY OF THE PERSON OF THE PERS THE REPORT OF THE RESIDENCE OF THE RESID ADD ALLERON OF THE REST OF THE PARTY OF THE 在数字中的数字。 不行 计公共 医二甲基 经经济证明 网络西西亚海洋大学家 计图像电话电话 の数据の企画数学を上記したとうが数据である。また、企業には特別の数据を対象に対象を持ちま 证明的证据。1998年至1987年2月1日,1987年3月,1987年3月1日,中国中国中国共和国共和国共和国 在10年的第三人称单数的 Triple 1969 在20年,第二人是 1969 年度 1969 年度

ares.

Pathological surveys of the stand as a whole and studies on individual treas of an area representative of particular types and conditions have led to the following results applicable to moneyement and the centrol of disease: It has been possible to take definite steps in the application of forest mathology to forest management in that proper marking rules have been formulsted. These rules of er means whereby forest sanitation may be secured over mek areas where the value of the species of the tree out and the sconomic fectors allow of more intensive methods in the control of forest tree diseases. Since the aim of forestry is to produce future exone, the efforts of forest pathology work are linked with this, and the sim is to produce crops of maximum soundness and, therefore, of least loss. These rules have been applied to the principal forest types of District One and have been made conformable to the silvicultural practice as at present applied to these types.

In the control of discount special attention must be given to the removed of infected trees below and above the specified dismotor limits, on important phase brought out by the surveys and should not long be everlocked. Control messures are intimately associated with survey studies which have for heir aim the outablianment of an average are of earliest infection, which when based on the assumption that any rotation decided upon must be considered as approximate and that the autting plan and t provide for a reasonable losway in outting timber either before or extent it has reached the rotation are, becomes highly important. In the case of western white pine, for all

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STATE OF STA the early to definite a first of for earlies for aniet apart to the period of the contract of A THE RESERVE OF THE PROPERTY 为第二人第二万英型·BES 2018年11日 2018年11日 安美市的主编的最后的企业和 CONTRACTOR OF THE SECOND OF THE SECOND SECON Springer House States mile service of the service AND THE PERSON OF PERSON OF THE PERSON OF TH THE REAL PROPERTY OF THE PARTY the state of the second ON BUILD ON MARKET STATE OF THE PARTY OF THE

 principal rote found an age of warliest infection of 50 years was determined for the tree in several. For western hericak in the Pricat River region attacked by <u>TohinoContium tinctorium</u>, the average age of first intection for the river bottom type is approximately 44 years, and for the slope type 57 years.

The next step is to establish a pathological folling use, a limiting factor in rotation. his will be found to very with the species of true discuss concerned and the site (See U.A.D.A.Bulletin No. 799).

In considering the relative precised importance of these area the correct encomption, it would be no the to fix the rotation age sufficiently near the average age of infection so that there rould be no question about setually outing the timber, at least by the time the second joint is the life history of the stand was reached and thich has been designated as the age at which the decay becomes common and causes a serious economic loss.

The fact that these surveys bring out the fact that the amount of a day bears a certain relation to the age of a stand makes it possible to propere buil tobles civing the not parcentage for a range of age classes for such tree erecies.

These tables are of value to the ordinator in determining the ret percentage for such type of forest and replace the old empirical method of judging the amount and intent of defect.

Tables have been preserted for western white pine and western hemlock, as follows:

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Table of Bot Per Cents for Testern Hemlock

Western White Pine.

A.C. * Age class 7.R. = Frunk rot B.R. * Butt rot.

Bottom Alto

4.C.	: Western Reglook	1 Restern White Pire
XC180		
41-60	0 6.0	: 0 - 0
OTALL CONTRACTOR	1 6 6 -16 0	
81-100	: 12.5 19.0	Selection 1/6-5-1/2-50
		.75 -1.7
2.3-1.00	1 20.5 53.0	: 1.8 - 5.1
161-200	: 33.540.0	1 3.8 -18.7
201-	: 40.560.0	: 15.8 -18.3

Slope Sito

\$1-60 - 61-60	1 0 1.0	
	: 1.1- 2.5	
	: 2.6- 3.5	: .0737
101-120	: 3.6 15.5	
121-160	1 15.6- 24.5	.46~ 2.3
101-200	: 24.6 88.0	
101-	33.1 37.0	1 8.8 -14.7

Hemlock figures from studies made near Privat River. Idaho, based on 201 trees.

White pine flaures from studies made on the Coeur d'Alene Bational Forest, Daho, based on 1,245 trees.

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to determine the influence of thinning on the remaining trees.
The studies so far made show the effects on uporophore development in that their activities are greatly curtailed thus lessening the chances of infecting the remaining or future stand.
This is in addition to the value to be derived from such studies as regards forest management.

Lastly, it is recommended that the Forest Service should carry out, so far as is practicable, all phases of forest sanitation work. By this is meant the direct supervision by Forest officers of all stages in the administration of timber sales which have to do with freeing the area of infactious material threatening new growth and the remaining stand. This is better than to leave so much of the semitation work in the hands of the operator.

seed tree groups through the rotting and weakening of roots by fungi is another important consideration in disease control, and is also important from a financial standpoint. Seed trees, whether left singly or in groups, are in many cases the sale source to be depended upon for the restocking of the cut-over areas. If, then, trees are not selected properly, and heart-rotted or butt-rotted trees are left on the area, the weakening of the roots coupled with the exposure due to the outling operations will result in windfalls and the trees will be lost as well as the potential value in respect to restocking the area with new growth. This also applies so far as the estual value

The series of the file of a series of the se

of the trees is concerned, to trees marked to be reserved in selection outlines. These trees should be free from root. butt and trunk rote. The opening up of the chanks by selection outling exposes the remaining trees to the force of the wind, and if trees are left whose roots or trunks are weakened by fungi, winsfall will result in one once and wind breakage in the other.

The estimated loss due to fungi in causing windfall amounts to \$23,642 in Forest Dervice, Districts One, Two, and Six. This comprises 3 per cent of the total loss. In western white pine loft as seed trees on out-over areas in the Cocur d'Alene National Forest approximately 50 per cent of these trees were a complete less due to windfall caused by fungi. Loss due to windfall by fungous attack in seed trees or in trees marked to be reserved in selection cuttings can be prevented by a strict enforcement of a general accomentation aiming to select trees free from root, butt, and trunk rote. The temand for a large out frequently prevents the adoption of many things known to be good forestry.

there are many opportunities calling for an application of the knowledge of excet tree discusse and leads to better forest cantation. A scaler who has been trained to recomise all the signs and indications which give him a better understanding of how the rot in the log extends will unquestionably come near we determining the correct scale of that log then one who has not. Each get in most cases caused by a distinct fungus has

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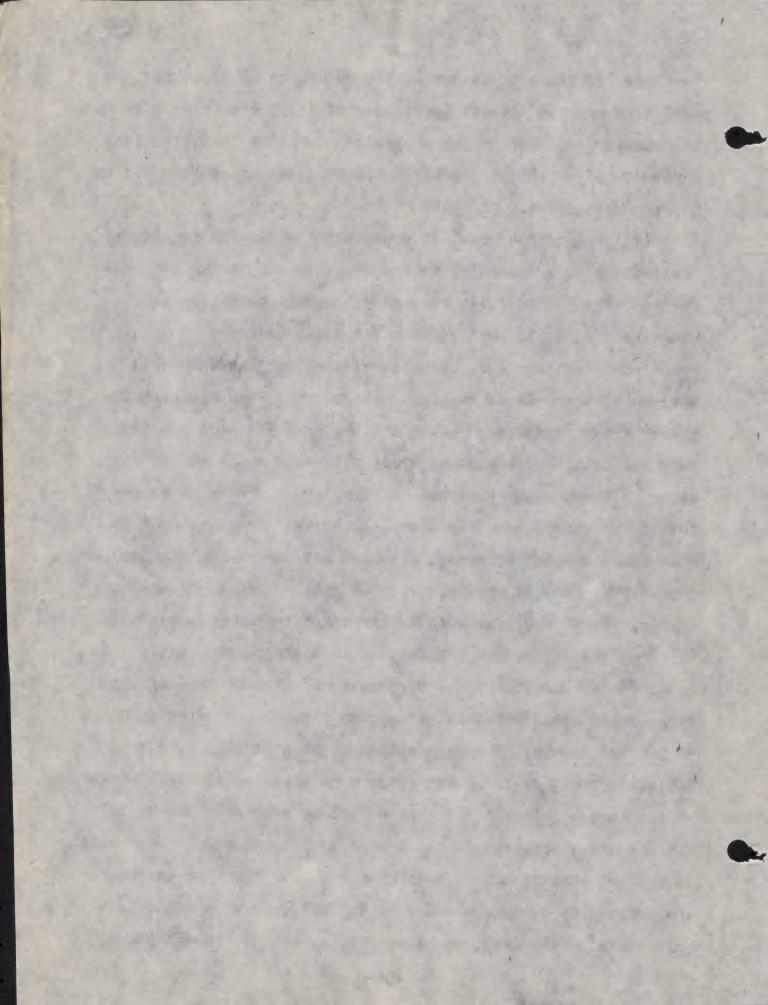
the femiliary of matches a continue allege determines for the

its our peculicrities and behaves differently as to its spread in the tree. Also the same rot varies in its method of attack on the wood, in come cases acting as a typical butt rol, asain on a heart rot. Donetimes it is patchy in habit, again it will be found to extend uniformly in the heartwood. These and many other points of practical value to scalers should be carefully studied and recorded so that the men who must be depended on for the correct scaling of the loss can be better equipped to bandle these varying conditions. In this case setual saving can be practiced in the correct scaling of infected logs so that neither a waste is incurred by overlooking merchantable sound material or overestimating the cull nor a lose incorred by unferestimating the cull and so ellowing loss to be shipped to the mills and there found weeker. In scaling heelook and grand fir logs, it is particularly important that the scalor recognise the earlier stages of the rot caused in the hourtwood by the Indian point rungua. The early stages of decay in this instance is very difficult to detect and if the logs are ellowed to go to the mill as sound material, upon outting not beards and during the drying process, it will be found that many of the borris fall into dry cruebly decay. The action of the fuerus in the heartwood does not become noticed by provincet until the boards dry. A knowledge of the characteristics of the rot applied through the mosler may in many instances save considerable money by preventing infected material from being saved into bourds and then found to be mmerchantable. There are as many more applications of this method of saving by way of correct scaling

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each tree species present problems distinctly characteristic and the knowledge concerning them should be applied in a technical manner in ofter to get the highest returns on soney invested in lossing operations.

(7) One of the greatest opportunities for the immediate realization of a finemoial return from forest growth and a reduction of the entirities of cull-producing funct lies in the production of pulp. Modern life has found uses for word ralp practically without end. Pulp as narufactured from various species of trees is of varying quality and is consequently exployed for various surposes. In timer post the best suclity pulp was cotained from thise trees with wood composed of lang strong filters, such as spruce and fir. The researches of the Porcet Products Laboratory have Laconstrated that the west of many other species of trees, although not possessing the cardities of the rood of spruce, produces gutp of great value in the trades. Up to the year 1915 no investigator had pointed out the fact that there are million of feet of standing living trees in the forests of the Morthwest attacked by delimifying forgi which would possibly be male to yield large sunntities of low grade pulp. The suggestion was node in 1915 by the District Forest Pathologist after some experimentation that the wood of trees infected with the collulous producing funci and which was not accepted in the trades even as common lumber would in all probability make a fair grade of pulp for some purposes. The magnestion of using such wood for pulp, in view of the requirements in the case, soons on the face of it sitemather un-



tenable. A publication by Weir shows the possibilities of using fungous infected trees for pulp.

purposes would rosalt in a tremendous saving in two ways.

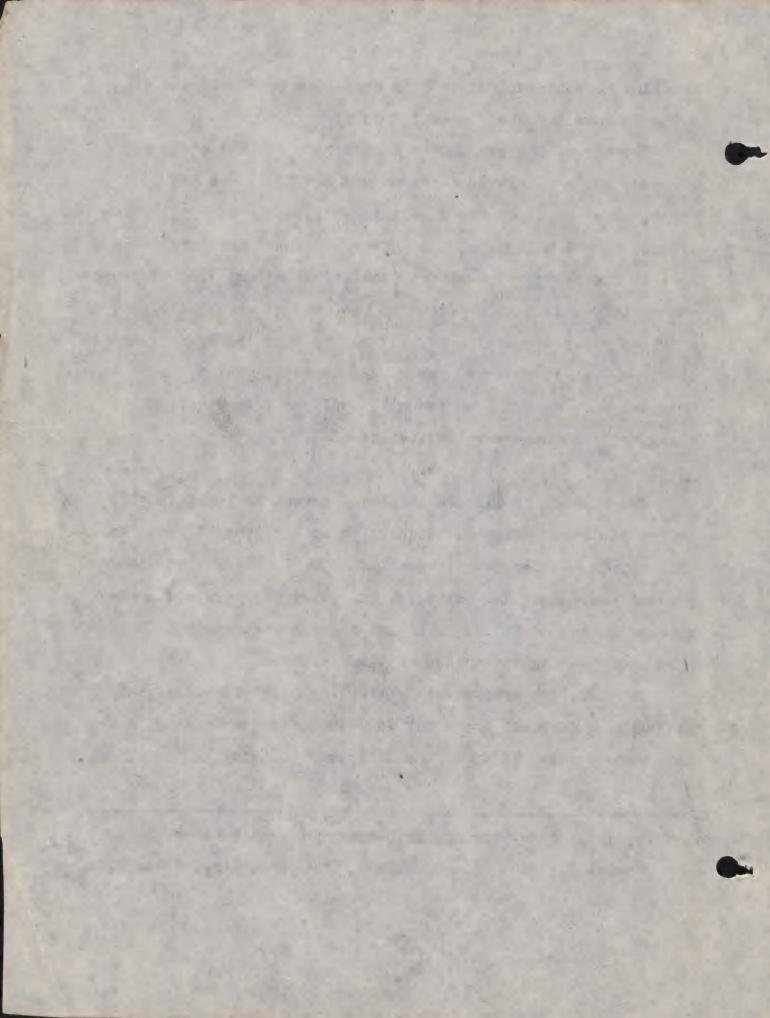
First, there would be the immediate utilization of rapidly deelining forest materials, the sep-use of which would entail great
cost in freeing the forest from infectious material. This would
undoubtedly result in a saving in the cost of slash disposal,
which at the present time is paid to the operator by a reduction
of stumpage. It must be remembered, however, that the cost of
bringing such material to the mill would be very great, unless
the conditions were very favorable.

Conclusion:

The control of disease in living forest is possible only in but few cases after infection. Under the present state of forestry in the Northwest large and seneral measures of disease control are out of the question. Sanitary and hygienic measures as indicated in the foregoing pages commonwrate with our rest secured conditions can only be followed.

Briefly, the suscessful application of these principles siming to reduce rot and decay in future forcets depends in the main upon a recognition of the following points:

Weir, J.H. Home Problems in Conservation with Reference to Forest Hygiene. The Timberson, Portland, Ore., Sept. 1913.



- 1. Recognition of the outward signs and symptoms of the various diseases of standing living trees.
- 2. Fairly accurate jusquent of the extent of rot in each tree found to be attacked by fungi, rusts and mistletce.
- 3. Enowledge of the age of first infection of various species of trees.

Special considerations siming to control forest diseases through timber sale operations are included with the marking rules for the individual stands and types. In general, this means the inclusion of a rigid forest sanitation clause in all timber sale contracts involving the utilisation or the destruction by fire of all infectious oull material, as well as all infected unmerchantable trees left standing.

